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Daily report 20-07-2020

Analysis and prediction of COVID-19 for EU-EFTA-UK and other countries

Situation report 104

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With the financial support of: MINISTERIO DE CIENCIA E INNOVACIÓN "la Caixa"

Foreword

The present report aims to provide a comprehensive picture of the **pandemic situation of COVID-19** in the EU countries, and to be able to foresee the situation in the next coming days.

We employ an **empirical model**, verified with the evolution of the number of confirmed cases in previous countries where the epidemic is close to conclude, including all provinces of China. The model does not pretend to interpret the causes of the evolution of the cases but to permit the **evaluation of the quality of control measures made in each state** and a **short-term prediction of trends**. Note, however, that the effects of the measures' control that start on a given day are not observed until approximately 7-10 days later.

The model and predictions are based on two parameters that are daily fitted to available data:

- ✓ *a*: the velocity at which spreading specific rate slows down; the higher the value, the better the control.
- ✓ *K*: the final number of expected cumulated cases, which cannot be evaluated at the initial stages because growth is still exponential.

We show an individual report with 8 graphs and a table with the **short-term predictions** for different countries and regions. We are adjusting the model to **countries and regions** with at least 4 days with more than 100 confirmed cases and a current load over 200 cases. The **predicted period** of a country depends on the number of datapoints over this 100 cases threshold, and is of 5 days for those that have reported more than 100 cumulated cases for 10 consecutive days or more. For short-term predictions, we assign higher weight to last 3 points in the fittings, so that changes are rapidly captured by the model. The whole methodology employed in the inform is explained in the last pages of this document.

In addition to the individual reports, the reader will find an initial dashboard with a brief analysis of the situation in EU-EFTA-UK countries, some summary figures and tables as well as **long-term predictions** for some of them, when possible. These long-term predictions are evaluated without different weights to data-points. We also discuss a specific issue every day.

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PJC and MC received funding from "la Caixa" Foundation (ID 100010434), under agreement LCF/PR/GN17/50300003; CP, DL, SA, MC, received funding from Ministerio de Ciencia, Innovación y Universidades and FEDER, with the project PGC2018-095456-B-I00;

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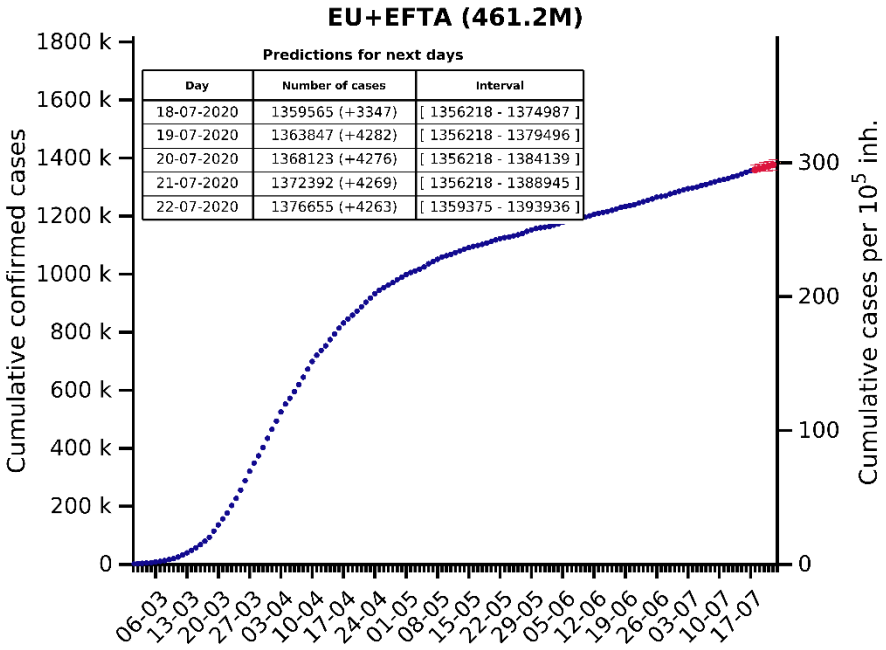
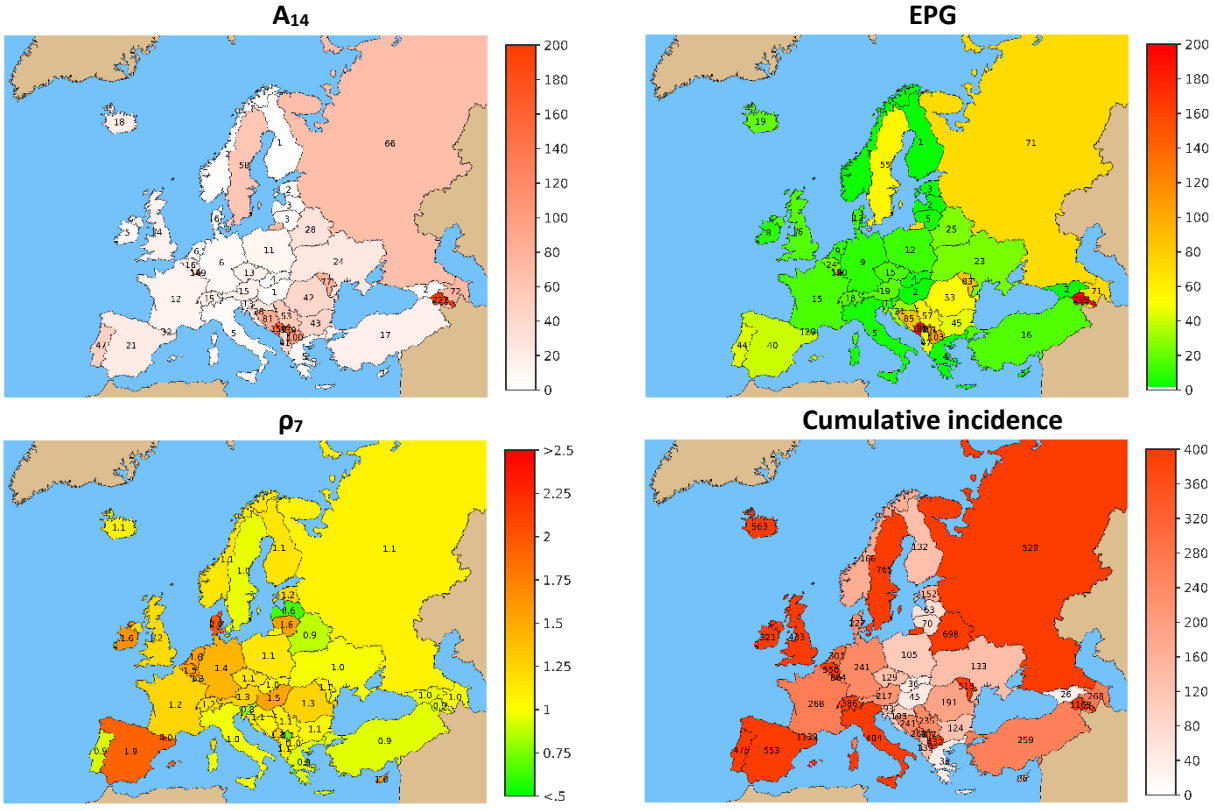
(0) Executive summary – Dashboard

Situation and highlights



Europe continues to show a situation where most countries have a ρ_7 above 1. In particular, **Spain** and **Denmark** show values around 2. Living with the presence of the virus requires adjusting control measures to maintain a sustainable situation. It would be desirable to reduce the number of daily new cases to be at least in the situation of countries such as the Netherlands or Switzerland, which corresponds to reducing social contacts to reach a Biocom-Cov degree of 2. The value of A_{14} is quite high in a few countries, as well: **Sweden** (423 per 10^5 inh.), **Luxembourg** (359), **Romania** (261), **Belgium** (241), **Spain** (228) and **France** (206). If these values decrease, these countries will make it possible to control each of the cases and their contacts (test and trace strategy).

The diagnostic effort in most European countries is currently higher than the one they had a few months ago. This means that the data on the number of daily new cases are not comparable with previous ones. We discuss this issue in the Analysis, and propose a simple method to allow comparison of new cases between different stages in the epidemic.



Situation and trends per country

Table of current situation in EU countries. Colour scale is relative except when indicated, this means that it is applied independently to each column, and distinguishes best (green) form worst (red) situations according to each of the variables. Last column (**EPG_{EST}**) is assessed with **estimated real 14-day attack rate** (see report from 22/04 for details). **EPG_{REP}** is calculated with **data reported by countries**. EPG_{REP} and EPG_{EST} **cannot be compared between them** because scales are different, but can be independently used for estimating risk of countries according to reported or estimated real situation, respectively. **Data from 2nd July.**

	Reported data								Indexes			
Country	Cumulative cases	Attack rate /10^5 inh.	Cumulative deaths	Mortality /10^5 inh.	Active cases (last 14 days)	14-day attack rate /10^5 inh.	Estimated active cases (last 14 days)	Estimated 14-day attack rate /10^5 inh.	ρ_7 [1]	EPG_{REP} [2]	EPG_{EST} [3]	Biocom-Cov degree
Spain	260.255	561,5	28.420	61,3	9.710	21,0	107.131	227,8	2,03	43	464	4
Italy	244.216	410,9	35.042	59,0	2.797	4,7	40.463	66,9	0,98	5	65	2
Germany	201.574	246,1	9.084	11,1	5.239	6,4	24.279	29,0	1,44	9	42	2
France	174.674	269,9	30.152	46,6	7.714	11,9	134.594	206,2	1,25	15	257	3
Sweden	77.281	785,5	5.619	57,1	5.862	59,6	42.740	423,2	0,96	57	405	6
Belgium	63.706	560,9	9.800	86,3	1.797	15,8	27.959	241,2	1,54	24	371	3
Netherlands	51.526	303,3	6.129	36,1	1.033	6,1	12.391	72,3	1,55	9	112	2
Portugal	48.390	466,5	1.684	16,2	4.821	46,5	17.475	171,4	0,92	43	158	5
Poland	39.746	104,0	1.618	4,2	4.027	10,5	17.053	45,1	1,14	12	51	3
Romania	36.691	185,5	2.009	10,2	8.109	41,0	50.236	261,1	1,26	52	329	6
Switzerland	33.406	389,8	1.687	19,7	1.292	15,1	6.841	79,0	1,17	18	93	3
Ireland	25.750	544,9	1.753	37,1	241	5,1	1.640	33,2	1,63	8	54	2
Austria	19.508	223,9	711	8,2	1.312	15,1	5.184	57,6	1,27	19	73	3
Czech Republic	13.855	130,6	358	3,4	1.415	13,3	4.050	37,8	1,15	15	43	3
Denmark	13.173	230,6	611	10,7	341	6,0	1.583	27,3	1,99	12	54	3
Norway	9.015	167,9	255	4,8	120	2,2	333	6,1	1,14	3	7	2
Bulgaria	8.638	121,1	299	4,2	2.961	41,5	13.442	193,5	1,06	44	205	5
Finland	7.318	133,0	328	6,0	48	0,9	225	4,1	1,15	1	5	1
Luxembourg	5.409	939,1	111	19,3	933	162,0	2.245	358,7	1,28	207	458	8
Hungary	4.315	44,2	596	6,1	132	1,4	1.905	19,7	1,53	2	30	2
Croatia	4.235	100,5	120	2,8	1.141	27,1	4.027	98,1	1,10	30	108	4
Greece	3.983	35,6	194	1,7	472	4,2	2.475	23,7	0,93	4	22	2
Estonia	2.021	154,0	69	5,3	28	2,1	NA	NA	1,23	3	NA	1
Slovakia	1.976	36,3	28	0,5	227	4,2	NA	NA	1,05	4	NA	2
Slovenia	1.940	93,4	111	5,3	261	12,6	1.645	79,1	0,85	11	67	3
Iceland	1.922	527,6	10	2,7	62	17,0	NA	NA	1,06	18	NA	3
Lithuania	1.915	65,9	80	2,8	84	2,9	NA	NA	1,55	4	NA	2
Latvia	1.189	60,3	31	1,6	66	3,3	NA	NA	0,63	2	NA	2
Cyprus	1.037	88,6	19	1,6	35	3,0	NA	NA	1,56	5	NA	2
Malta	674	157,1	9	2,1	2	0,5	NA	NA	NA	NA	NA	0
Liechtenstein	86	223,0	1	2,6	2	5,2	NA	NA	NA	NA	NA	1
Scale												
	Worst	Worst	Worst	Worst	Worst	Worst	Worst	Worst	2,0	100	1000	
	Best	Best	Best	Best	Best	Best	Best	Best	0,0	0	0	

Disclaimer: estimated active cases and estimated 14-day attack rate are assessed by assuming a lethality of 1 % (see report from 20 to 24 April, #37-41). This value can change in countries where suspicious deaths are reported as well (real values would be lower) and in countries where incidence among elderly people was minor (real values would be higher)

[1] ρ_7 is the average of 7 consecutive ρ, but can still fluctuate. [2,3] EPG stands for Effective Growth Potential. EPG_{REP} is the product of attack-rate of last 14 days per 10^5 inhabitants by ρ_7 (empiric reproduction number). EPG_{EST} is the product of estimated real attack-rate of last 14 days per 10^5 inhabitants and ρ_7. Biocom-Cov degree is an epidemiological situation scale based on the level of last week's mean daily new cases (https://upcommons.upc.edu/handle/2117/189661, https://upcommons.upc.edu/handle/2117/189808).

Analysis: Index for the comparison among number of cases with different diagnosis rates in the same country at different times.

From the beginning of the pandemic in March, the percentage of diagnosed cases has been, in general, continuously increasing in all the countries in the European Union. We have already studied such an increase in the reports #40 and #95[1]. Next, we show a table where we show the **evolution of the calculated diagnosis rate for different countries in the European Union**. This table is the extension of the previous table shown in report #95[1], where we have also included Spain because it has finished with the checking of the number of deaths. Note that we estimate the total number from the number of deaths and therefore we need both quantities, number of cases and number of deaths.

Table 1. Percentage of diagnosed cases from March to June (diagnostic rate, DR), monthly variation of these values and overall variation for EU+EFTA+UK countries

	March DR	April DR	March-April trend	May DR	April-May trend	June DR	May-June trend	Overall trend (March-June)
Austria	17%	28%	11%	16%	-12%	21%	5%	4%
Belgium	3%	5%	2%	9%	4%	13%	4%	10%
Bulgaria	12%	13%	2%	18%	5%	15%	-4%	3%
Denmark	22%	15%	-6%	28%	12%	36%	8%	14%
France	3%	5%	1%	7%	2%	13%	6%	9%
Germany	19%	23%	4%	17%	-7%	23%	6%	4%
Greece	11%	18%	7%	15%	-3%	19%	4%	8%
Hungary	3%	6%	3%	8%	2%	8%	0%	5%
Ireland	10%	12%	2%	19%	7%	14%	-5%	4%
Italy	3%	8%	5%	9%	1%	8%	-1%	5%
Netherlands	3%	7%	4%	11%	4%	21%	11%	19%
Poland	9%	14%	5%	21%	6%	30%	9%	21%
Portugal	4%	21%	17%	25%	4%	40%	15%	35%
Romania	8%	12%	4%	15%	3%	15%	0%	7%
Spain	2%	10%	8%	13%	3%	30%	17%	28%
Sweden	16%	5%	-11%	9%	4%	21%	12%	5%
Switzerland	12%	21%	9%	14%	-7%	18%	4%	6%
United Kingdom	1%	4%	3%	10%	6%	10%	0%	9%
EU+EFTA+UK	**4%**	**8%**	**4%**	**11%**	**3%**	**14%**	**3%**	**10%**

The main reason for this trend has been the generalized increase in the number of tests performed. In the following two figures we can observe this issue. In Figure 1 we see the cumulative number of tests and cases per 100,000 inhabitants, and the ratio between these two variables for Austria, Belgium, Italy, Spain, Switzerland and the UK. It should be noted that the y-axis of the graph is logarithmic, and the differences in the final values are not easily ascertained (cumulative cases per 10^5 inhabitants: Austria 200, Belgium 540, Italy 400, Spain 530, UK 470). It is observed that, **initially, the quotient between cases and test increases**, and then, the **rapid increase in the number of tests causes a progressive decrease in this ratio**.

[1] https://upcommons.upc.edu/handle/2117/184991, https://upcommons.upc.edu/handle/2117/191998

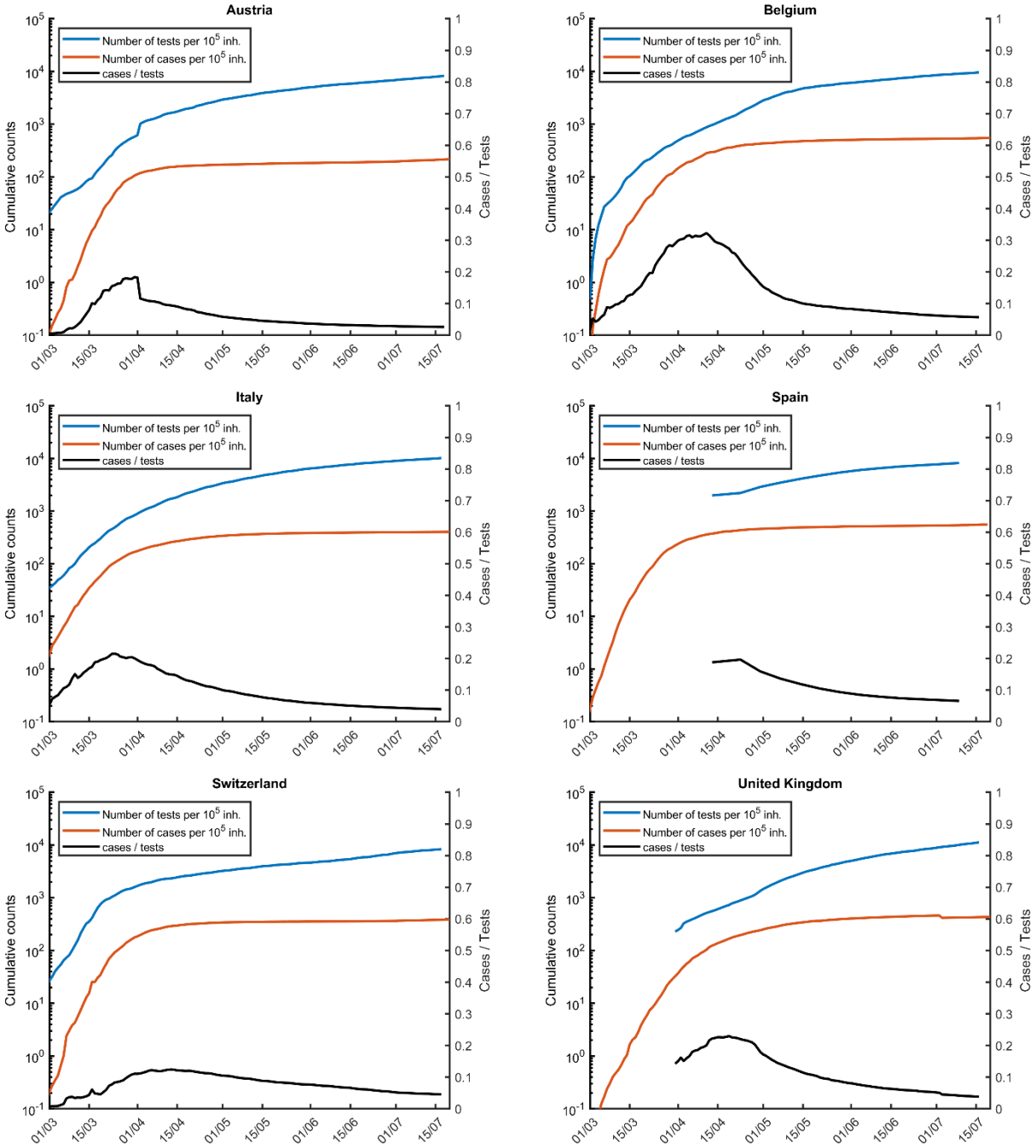


Figure 1. Cumulative number of tests and cases per 100,000 inh. and quotient between both variables.

These dynamics can be better visualized when we represent the daily testing level (DTL, tests performed daily per 100,000 inh.) and daily new cases per 100,000 hab. (Figure 2). Initially, the number of tests increased throughout the epidemic, but at a later stage we see how the DTL in some countries decreased or fluctuated. **From the moment the tests were massively used (DTL of 100-150 between the different European countries), it is observed that the percentage of positive tests falls.** In fact, at the beginning of the epidemic the number of cases detected depended largely on the tests performed and the percentage of positives was very high. The World Health Organization (WHO) has set a risk threshold based on the percentage of positives among performed tests, which **WHO suggests that should be below 5 %** for two weeks before reopening

countries[2]. Higher positive rates would indicate that testing effort is not enough and that a significant number of cases is being missed.

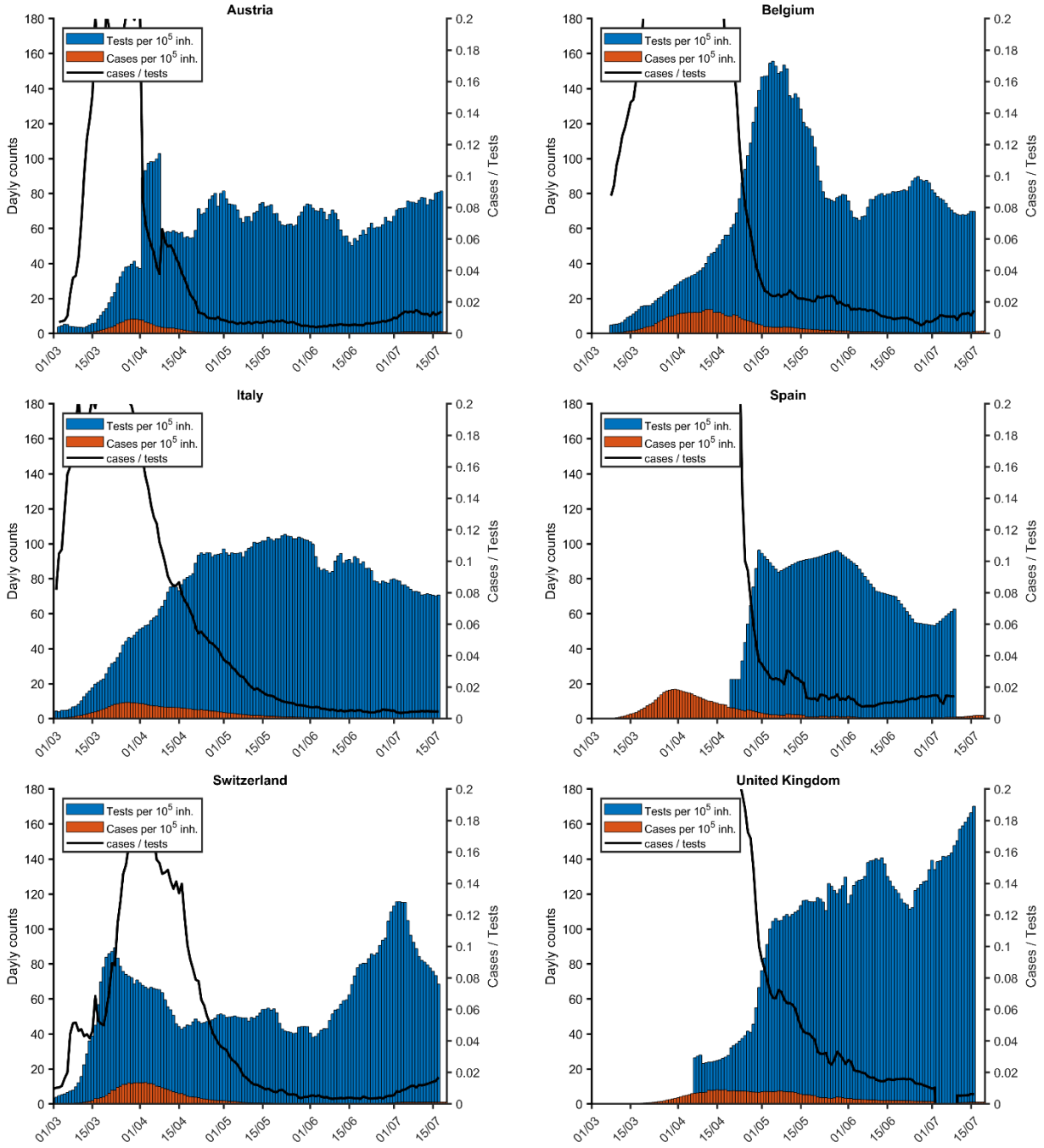


Figure 2. Daily tests and cases per 100,000 inh. In black, quotient between both magnitudes.

There is an important issue to keep in mind when assessing the percentage of positive tests: **not all the tests are used to test new patients**. In fact, a certain fraction of tests is used for checking the evolution of patients, in particular the negativization of the PCR. Therefore, the percentage of positive tests cannot be directly evaluated from the quotient between cases and tests. Italian government has published data that illustrates that between 50 and 60% of the tests are used to test new patient, while remaining tests are devoted to the follow-up of patients. This is shown in Figure 3.

[2] https://apps.who.int/iris/rest/bitstreams/1277773/retrieve

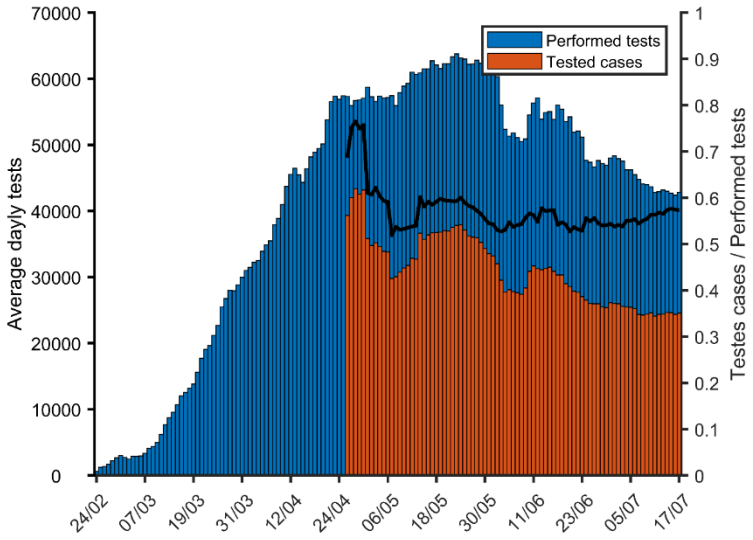


Figure 3. Number of daily performed tests (blue) and number of new cases tested every day (red). Black line shows the quotient between both magnitudes.

The increase in number of tests is essential to improve the picture of the situation and the control of the epidemics. Nevertheless, **an increase in the diagnosis rate prevents current number of cases to be compared with those of previous stages of this epidemic**. For instance, the 1,361 new cases that were registered in Spain on July 17 are not comparable to the 1,266 that were detected on March 14 in the same country. Next, we propose a new magnitude that pursues the validity of comparing of new cases along the epidemic: **it consists of re-scaling the number of new cases (N_{new}) with the percentage of positive tests divided by WHO recommendation (5 %)**. Ideally, we should directly use the percentage of positives among tests performed to new patients. Nevertheless, while these data are not specifically reported by countries, the quotient between new cases and performed tests can be used instead.

$$N_{new,re-scaled}(t) = N_{new}(t) \cdot \frac{\left(\frac{new\ cases}{performed\ tests}\right)_{country,t}}{\left(\frac{new\ cases}{performed\ tests}\right)_{reference}}$$

Then, the re-scaled magnitude would permit the comparison of the situation at different stages of the epidemic. In other words, 10 new re-scaled cases now would be equivalent to 10 new re-scaled cases on March (Figure 4).

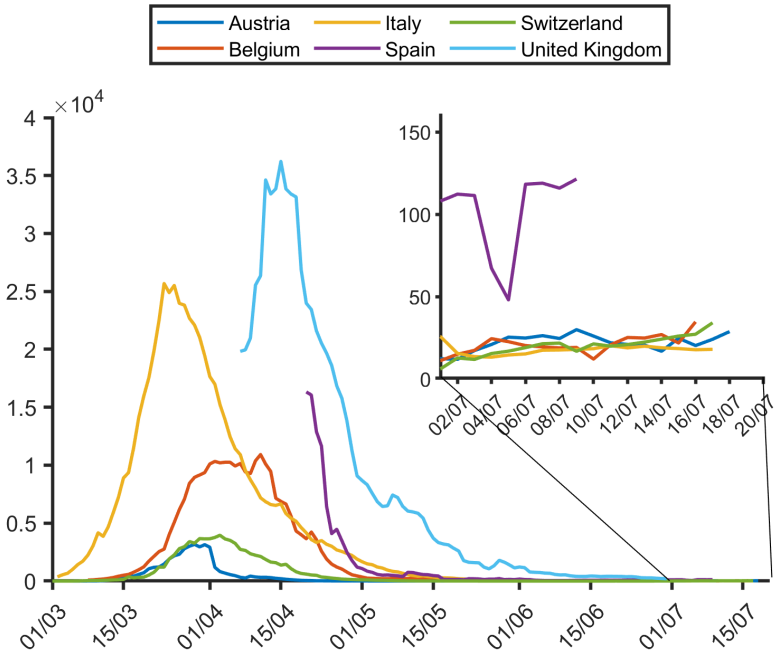


Figure 4. Re-scaled new cases in different European countries.

This new variable allows us the drawing of a **risk diagram that provides a more reliable history of the epidemic** in a country, since it facilitates the numerical comparison between different stages in the epidemic. Figure 5 presents the comparison of both risk diagrams for Italy. In the left, the standard risk diagram that is plotted using reported data. In the right, a risk diagram which is plotted using re-scaled new cases instead of reported. The colour code in the new risk diagram is still to be defined, since its meaning (possibility of tracing contacts with current DTL) is not directly exportable to the new one and requires further analysis.

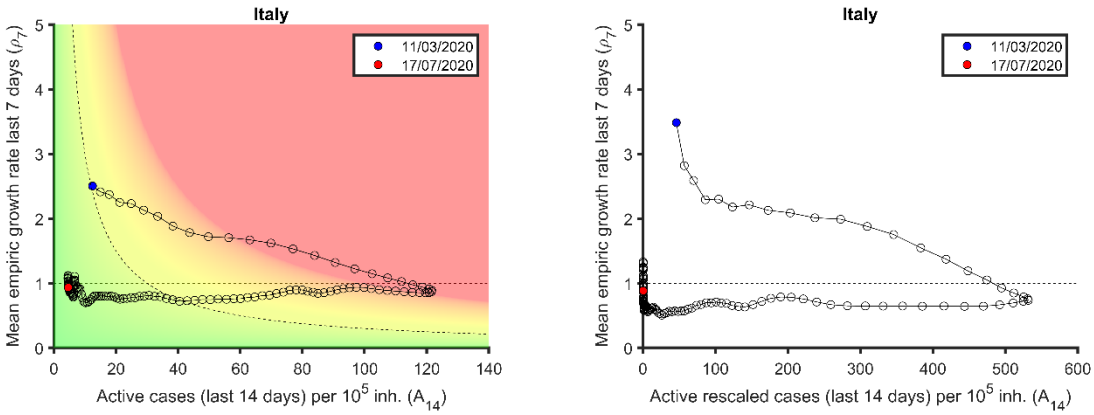


Figure 5. Risk diagram of Italy (left) and risk diagram using re-scaled new cases (right).

In conclusion, the diagnosis rate has been continuously increasing during the last month. This is because the number of tests has increased during the pandemic while the number of cases has strongly decreased. These new tests actually refer not only to new cases but also because of the evolution of the patients as we have from the Italian case. We can finally define a rescaled number of cases, taking into account the number of tests. **Such index permits to compare the situation corresponding to the new cases detected now in comparison with the cases detected some months ago.**

Situation and trends in other countries

Table of current situation in a sample of non-EU countries. Colour scale is relative except when indicated, this means that it is applied independently to each column, and distinguishes best (green) form worst (red) situations according to each of the variables. EPG_{REP} and EPG_{EST} **cannot be compared between them** because scales are different, but can be independently used for estimating risk of countries according to reported or estimated real situation, respectively. **Data from 2nd July.**

	Reported data								Indexes			
Country	Cumulative cases	Attack rate /10^5 inh.	Cumulative deaths	Mortality /10^5 inh.	Active cases (last 14 days)	14-day attack rate /10^5 inh.	Estimated active cases (last 14 days)	Estimated 14-day attack rate /10^5 inh.	ρ_7 (1)	EPG_{REP} (2)	EPG_{EST} (3)	Biocom-Cov degree
United States of America	3.711.464	1.121,3	140.119	42,3	871.922	263,4	3.761.761	1.136,5	1,11	293	1.262	9
Brazil	2.074.860	976,1	78.772	37,1	497.856	234,2	2.054.862	966,7	0,97	226	935	9
India	1.077.618	79,6	26.816	2,0	404.453	29,9	1.157.295	85,5	1,20	36	103	5
Russia	771.546	528,7	12.342	8,5	97.031	66,5	NA	NA	1,07	71	NA	6
Peru	349.500	1.060,0	12.998	39,4	50.420	152,9	209.532	635,5	1,09	166	691	8
Mexico	338.913	262,9	38.888	30,2	86.748	67,3	1.093.017	847,7	1,01	68	857	6
Chile	326.539	1.708,2	8.347	43,7	34.692	181,5	95.620	500,2	0,84	153	422	8
Iran	271.606	323,4	13.979	16,6	33.728	40,2	179.668	213,9	0,99	40	211	5
Pakistan	263.496	119,3	5.568	2,5	35.022	15,9	76.287	34,5	0,78	12	27	3
Saudi Arabia	248.416	713,6	2.447	7,0	42.487	122,0	NA	NA	0,86	105	NA	7
Argentina	119.288	263,9	2.204	4,9	46.515	102,9	96.552	213,6	1,03	106	219	7
Canada	109.658	290,5	8.839	23,4	4.353	11,5	35.990	95,4	1,17	14	112	3
Qatar	106.308	3.689,9	154	5,3	7.125	247,3	NA	NA	0,86	213	NA	8
Ecuador	73.382	415,9	5.282	29,9	11.847	67,1	101.676	576,3	1,12	75	644	6
Belarus	65.953	698,0	495	5,2	2.683	28,4	NA	NA	0,87	25	NA	4
	Scale											
	Worst	Worst	Worst	Worst	Worst	Worst	Worst	Worst	2,0	100	1000	
	Best	Best	Best	Best	Best	Best	Best	Best	0,0	0	0	

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Time indicators by country

These tables summarize a few time indicators for each country: time since 50 cases were reported, time interval between an attack rate of $1/10^5$ inhabitants and an attack rate of $10/10^5$ inhabitants, and time interval between attack rates of 10 to 100 per 10^5 inhabitants (only for countries that have overtaken this threshold). **Data from 2nd July.**

EU+EFTA+UK countries

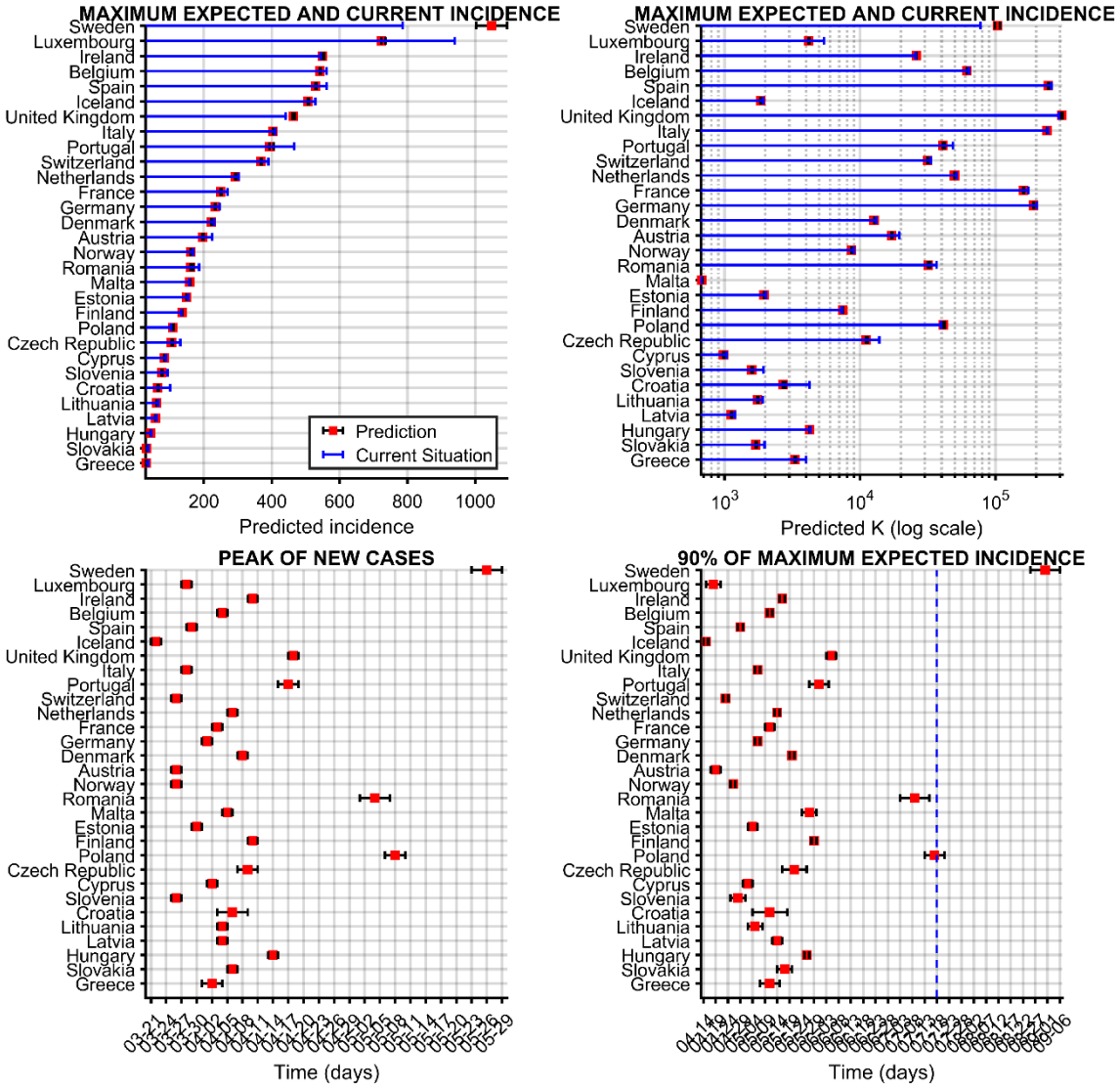
Countries	Days since the first 100 cases	Time interval between 1 and 10 cases / 10^5 inh. (days)	Time interval between 10 and 100 cases / 10^5 inh. (days)
Italy	147	11	16
Germany	141	12	17
France	140	10	20
Spain	140	8	12
Belgium	137	10	15
United Kingdom	136	10	12
Netherlands	135	11	20
Sweden	135	10	28
Norway	135	2	7
Switzerland	135	8	11
Austria	133	10	14
Denmark	132	4	30
Czech Republic	129	11	94
Finland	129	12	46
Greece	129	18	NA
Iceland	129	5	15
Portugal	128	9	15
Slovenia	128	6	NA
Estonia	127	5	30
Ireland	127	8	18
Poland	127	17	101
Romania	127	15	66
Luxembourg	124	6	7
Slovakia	123	24	NA
Bulgaria	122	30	88
Croatia	122	12	NA
Hungary	121	20	NA
Latvia	121	12	NA
Lithuania	120	9	NA
Malta	119	9	35
Cyprus	118	12	NA

Other countries

Countries	Days since the first 100 cases	Time interval between 1 and 10 cases / 10^5 inh. (days)	Time interval between 10 and 100 cases / 10^5 inh. (days)
Iran	144	11	42
United States of America	139	8	15
Canada	130	11	27
Qatar	130	3	31
Brazil	127	20	34
Saudi Arabia	126	21	29
Chile	125	13	36
Pakistan	125	35	59
India	125	38	NA
Russia	124	15	24
Peru	124	18	22
Ecuador	124	10	30
Mexico	123	25	47
Argentina	122	39	54
Belarus	111	10	18

Long-term predictions

Evaluated with the **whole historical series**. Up-left: Predictions of maximum incidences per country **at the end of the first wave** (total final expected attack rate per 10^5 inh.). Up-right: Predictions of maximum absolute number of cases per country at the end of the first wave (K, in log scale). Blue lines indicate current situation. Bottom-left: Time in which peak in new cases was achieved / will be achieved. Bottom-right: Time at which 90 % of K was achieved / will be achieved. Blue dotted line indicates current date.



Final expected value for EU+EFTA+UK as a whole is not shown any more, since we are in the tail (see Analysis section in Report #87, https://upcommons.upc.edu/handle/2117/190497).

Situation and trends in Italian and Spanish regions

Italy

Data from **20th July**

	Reported data								Indexes			
Country	Cumulative cases	Attack rate /10^5 inh.	Cumulative deaths	Mortality /10^5 inh.	Active cases (last 14 days)	14-day attack rate /10^5 inh.	Estimated active cases (last 14 days)	Estimated 14-day attack rate /10^5 inh.	ρ_7 (1)	EPG_{REP} (2)	EPG_{EST} (3)	Biocom-Cov degree
Lombardia	95,548	951.5	16,796	167.3	1,021	10.2	18,314	182.0	0.77	8	141	3
Piemonte	31,537	723.9	4,120	94.6	108	2.5	1,407	32.3	0.65	2	21	1
Emilia Romagna	29,220	655.2	4,277	95.9	545	12.2	8,032	180.1	1.14	14	206	3
Veneto	19,649	400.5	2,050	41.8	322	6.6	3,370	68.7	2.54	17	174	3
Toscana	10,375	278.2	1,130	30.3	88	2.4	916	24.6	2.01	5	49	2
Liguria	10,105	651.7	1,565	100.9	104	6.7	1,627	104.9	2.35	16	247	3
Lazio	8,450	143.7	851	14.5	245	4.2	2,553	43.4	0.85	4	37	2
Marche	6,811	446.5	987	64.7	21	1.4	298	19.5	1.02	1	20	1
Trento	4,889	455.9	405	37.8	16	1.5	126	23.4	1.50	2	35	2
Campania	4,833	83.3	433	7.5	87	1.5	854	14.7	1.65	2	24	2
Puglia	4,557	113.1	548	13.6	21	0.5	256	6.3	2.34	1	15	1
Friuli Venezia Giulia	3,356	276.2	345	28.4	30	2.5	304	25.0	2.33	6	58	2
Abruzzo	3,342	254.8	468	35.7	33	2.5	469	35.7	0.80	2	29	2
Sicilia	3,144	62.9	283	5.7	49	1.0	446	8.9	3.73	4	33	1
Bolzano	2,684	2,498.2	292	271.8	37	34.4	401	76.9	0.77	26	59	2
Umbria	1,456	165.1	80	9.1	9	1.0	NA	NA	1.76	2	NA	1
Sardegna	1,379	84.1	134	8.2	8	0.5	82	5.0	2.36	1	12	1
Calabria	1,239	63.6	97	5.0	56	2.9	NA	NA	2.14	6	NA	2
Valle dAosta	1,196	952.2	146	116.2	0	0.0	0	0.0	0.00	0	0	0
Molise	446	145.9	23	7.5	1	0.3	NA	NA	0.14	0	NA	0
Basilicata	408	72.5	28	5.0	4	0.7	NA	NA	NA	NA	NA	1
Scale												
	Worst	Worst	Worst	Worst	Worst	Worst	Worst	Worst	2.0	100	1000	
	Best	Best	Best	Best	Best	Best	Best	Best	0.0	0	0	

Spain

Data from **10th July**. Symptoms onset date.

	Reported data								Indexes			
Country	Cumulative cases	Attack rate /10^5 inh.	Cumulative deaths	Mortality /10^5 inh.	Active cases (last 14 days)	14-day attack rate /10^5 inh.	Estimated active cases (last 14 days)	Estimated 14-day attack rate /10^5 inh.	ρ_7 (1)	EPG_{REP} (2)	EPG_{EST} (3)	Biocom-Cov degree
Madrid	72,874	1,097.4	8,393	126.4	570	8.6	6,605	99.1	1.02	9	101	3
Catalunya	59,830	790.9	5,674	75.0	3,422	45.2	33,863	441.2	1.57	71	692	6
Castilla y Leon	26,756	1,111.1	2,794	116.0	136	5.6	1,447	60.3	0.84	5	50	2
Castilla-La Mancha	22,215	1,091.4	2,909	142.9	216	10.6	2,830	139.2	1.07	11	149	3
Andalucia	17,083	202.7	1,427	16.9	334	4.0	2,952	35.1	1.18	5	41	2
Comunitat Valenciana	15,065	302.8	1,431	28.8	219	4.4	2,103	42.0	1.03	5	43	2
Euskadi	14,798	679.4	1,562	71.7	202	9.3	2,132	96.6	1.99	18	192	3
Galicia	10,964	406.0	619	22.9	239	8.9	1,358	50.3	1.61	14	81	2
Navarra	7,895	1,214.7	529	81.4	98	15.1	653	99.8	1.84	28	184	5
Aragon	7,287	551.7	908	68.7	538	40.7	7,498	568.4	1.47	60	837	7
Extremadura	5,737	538.5	518	48.6	94	8.8	927	86.8	1.46	13	126	4
La Rioja	4,010	1,278.8	366	116.7	13	4.1	138	43.6	2.36	10	103	3
Murcia	2,559	172.0	147	9.9	74	5.0	436	29.2	1.77	9	52	2
Canarias	2,533	114.8	162	7.3	38	1.7	240	11.1	2.22	4	25	2
Asturias	2,439	238.6	334	32.7	4	0.4	60	5.8	0.71	0	4	1
Baleares	2,387	201.0	224	18.9	60	5.1	549	47.8	0.75	4	36	2
Cantabria	2,364	406.4	208	35.8	15	2.6	125	21.5	1.54	4	33	2
Ceuta	222	261.7	4	4.7	0	0.0	NA	NA	NA	NA	NA	0
Melilla	140	165.3	2	2.4	0	0.0	NA	NA	NA	NA	NA	1
Scale												
	Worst	Worst	Worst	Worst	Worst	Worst	Worst	Worst	2.0	100	1000	
	Best	Best	Best	Best	Best	Best	Best	Best	0.0	0	0	

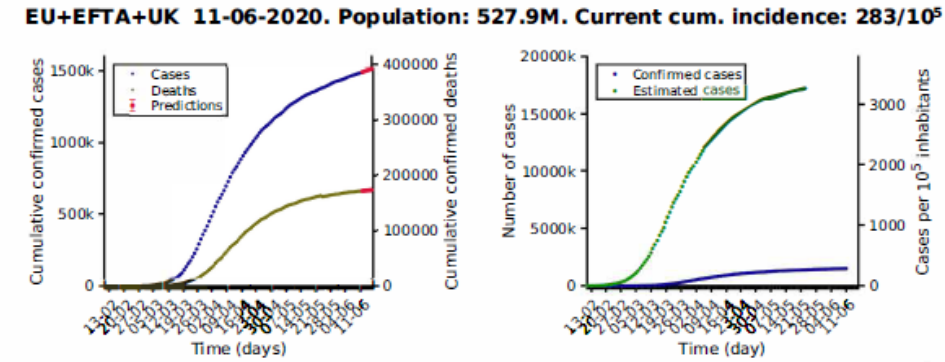
Disclaimer: estimated active cases and estimated 14-day attack rate are assessed by assuming a lethality of 1 % (see report from 20 to 24 April, #37-41). This value can change in countries where suspicious deaths are reported as well (real values would be lower) and in countries where incidence among elderly people was minor (real values would be higher).

(1) ρ_7 is the average of 7 consecutive ρ, but can still fluctuate. (2,3) EPG stands for Effective Growth Potential. EPG_{REP} is the product of attack-rate of last 14 days per 10^5 inhabitants by ρ_7 (empiric reproduction number). EPG_{EST} is the product of estimated real attack-rate of last 14 days per 10^5 inhabitants and ρ_7. Biocom-Cov degree is an epidemiological situation scale based on the level of last week's mean daily new cases (https://upcommons.upc.edu/handle/2117/189661, https://upcommons.upc.edu/handle/2117/189808).

Long-term predictions are not shown any more, since all Italian and Spanish regions are already in the tail (see Analysis section in Report #87, https://upcommons.upc.edu/handle/2117/190497).

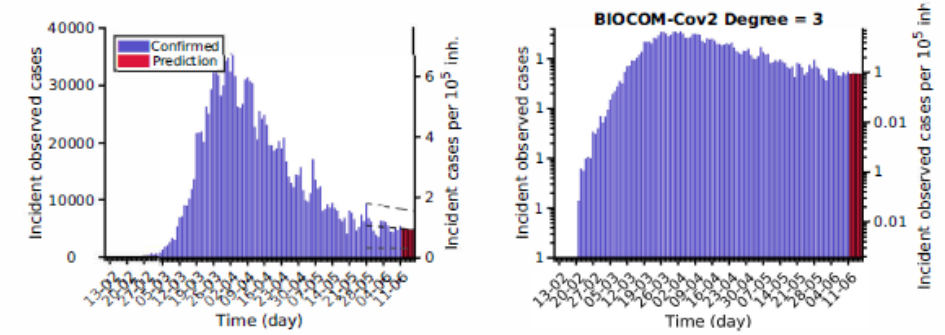
Legend: Countries' reports details

Reported cumulative cases (blue) and deaths (brown), together with predictions (red



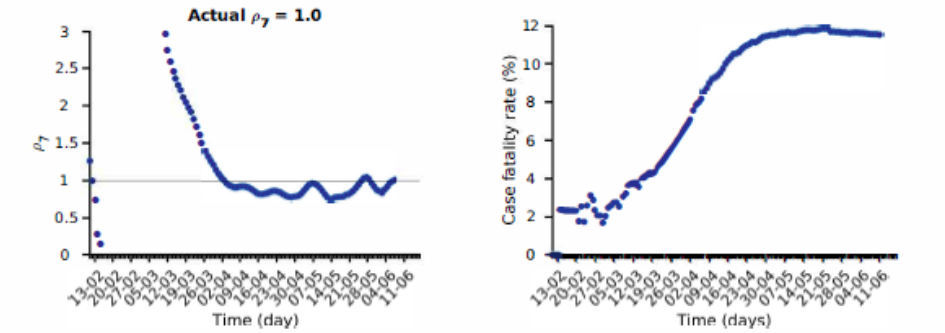
Estimated and reported cases.

Incident observed cases and predictions.



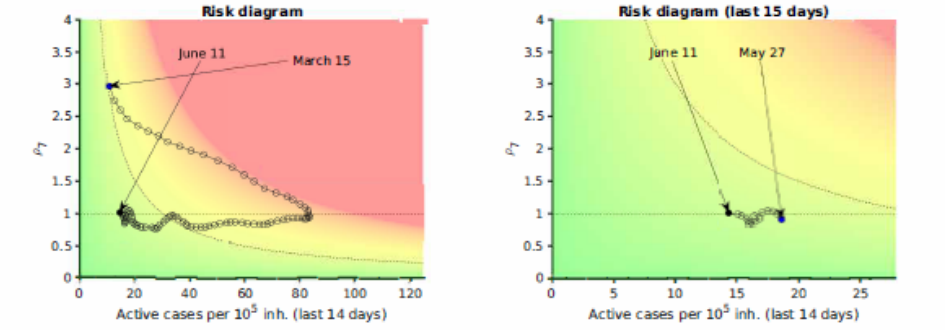
Incident observed cases in a logarithmic scale, with Biocom-Cov degree.

Evolution of empiric reproductive number ρ_7



Case fatality rate

Risk diagram

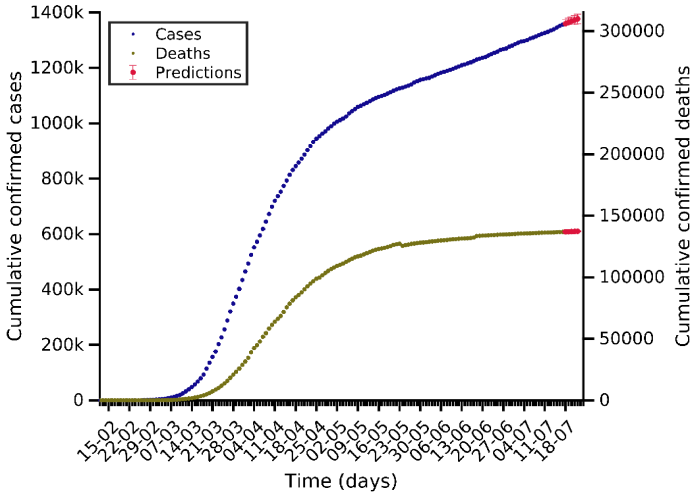


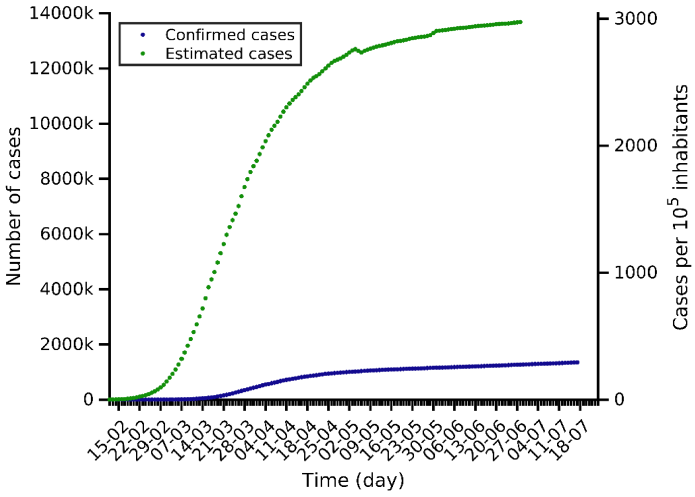
Risk diagram of last 15 days

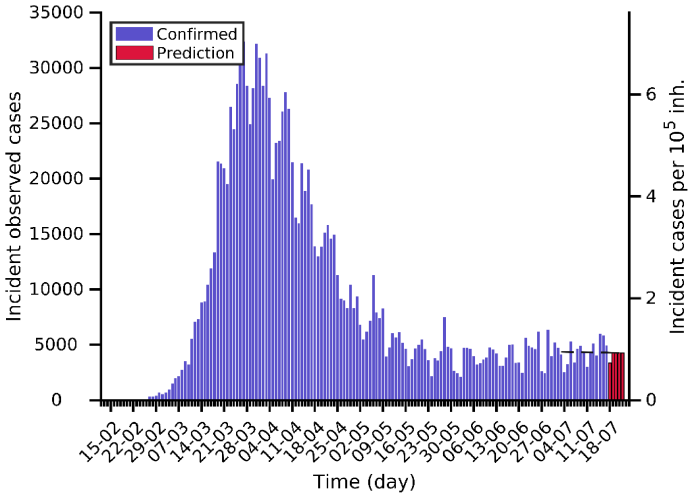
(1) Analysis and prediction of COVID-19 for EU+EFTA+UK

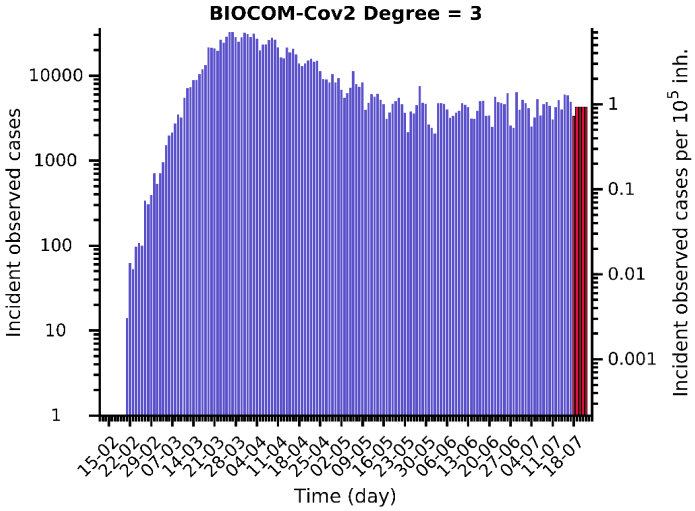
Data obtained from https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases

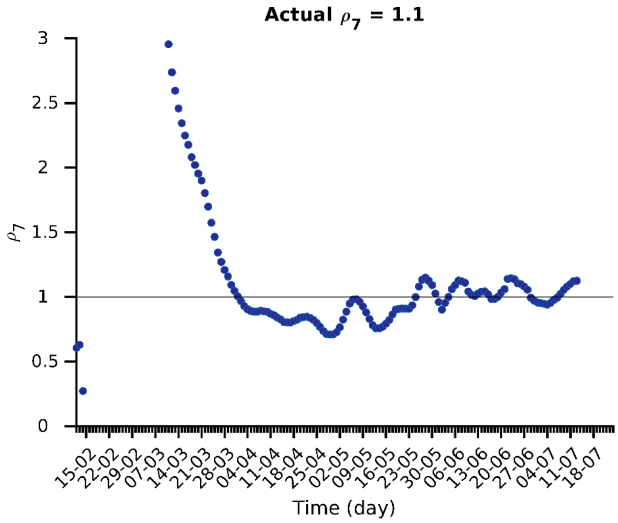
EU+EFTA 18-07-2020. Pop: 460.0M. Cumulative incidence: 295/10⁵

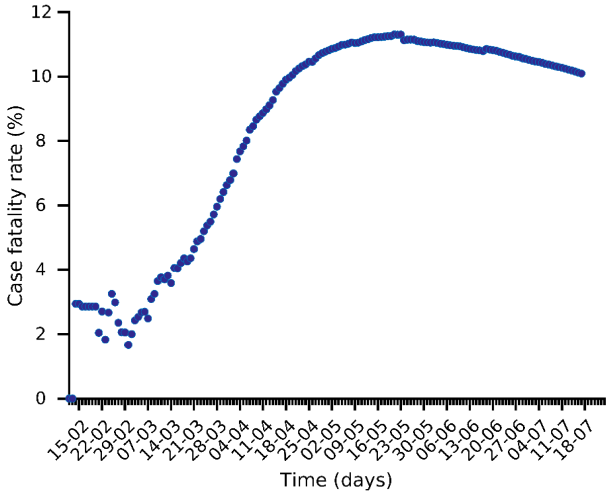


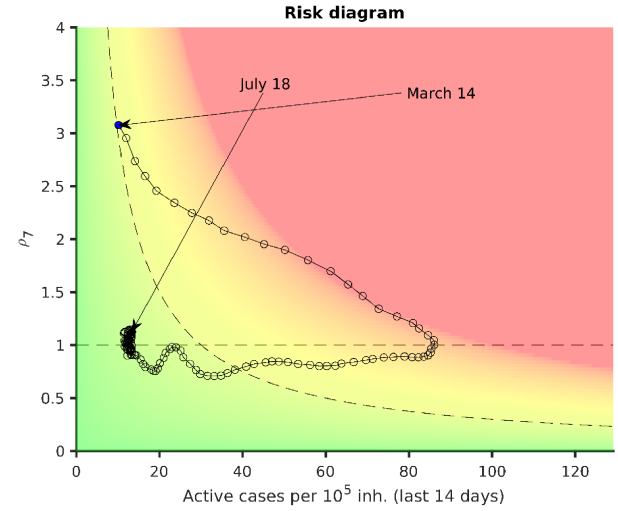


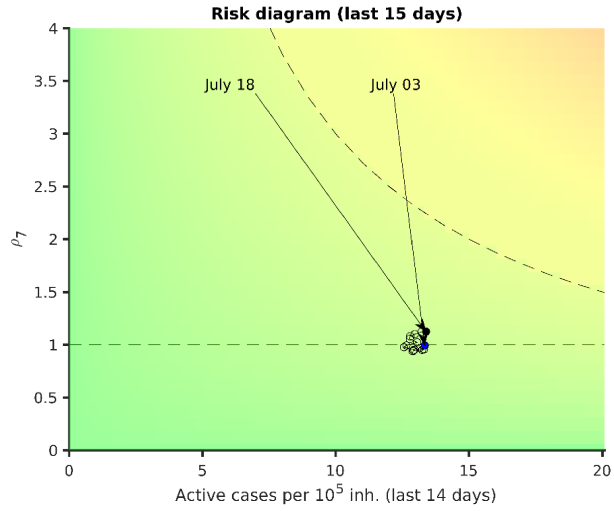




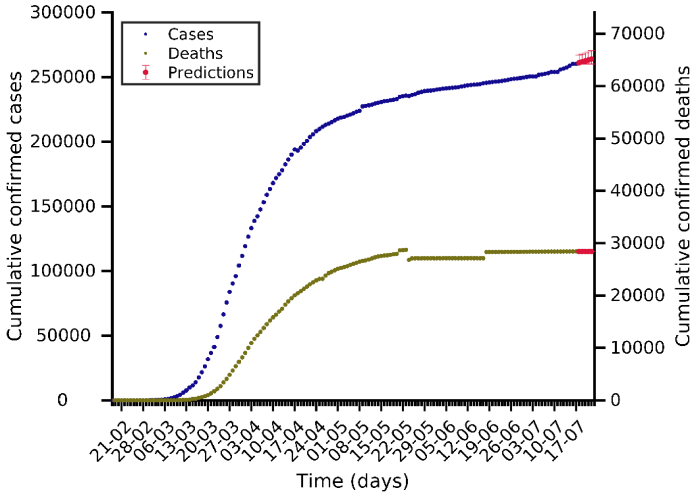


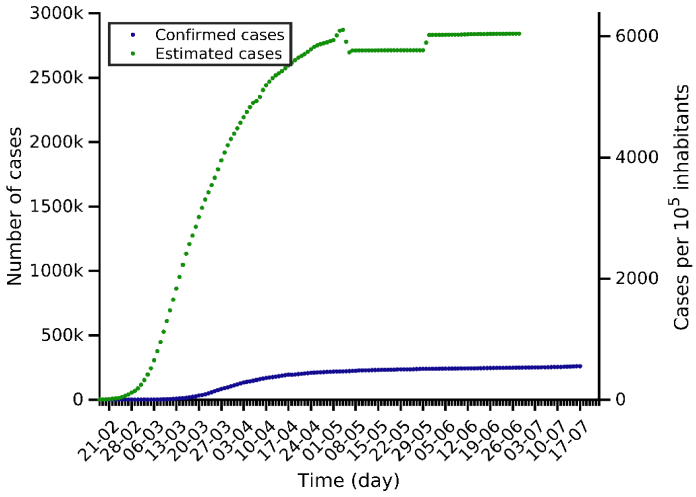


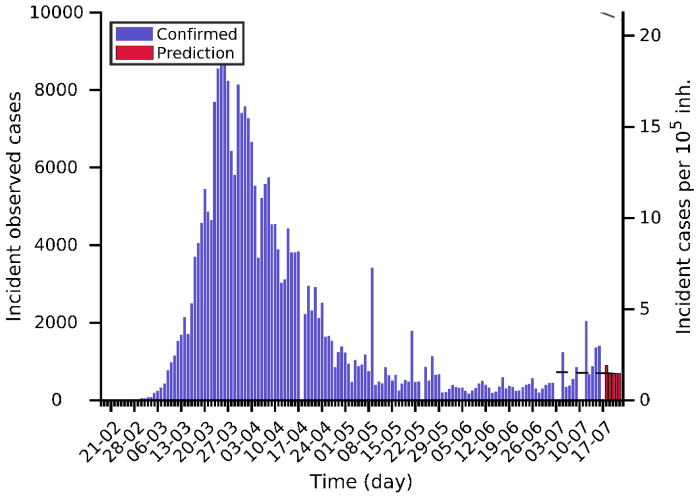


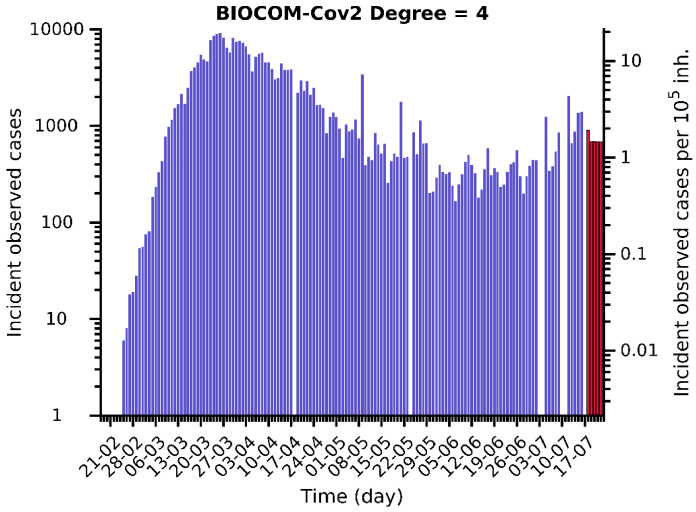


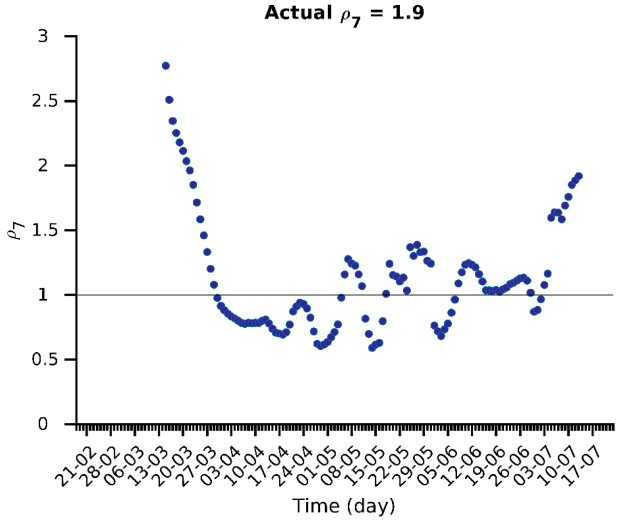
Spain 17-07-2020. Pop: 47.0M. Cumulative incidence: 553/10⁵

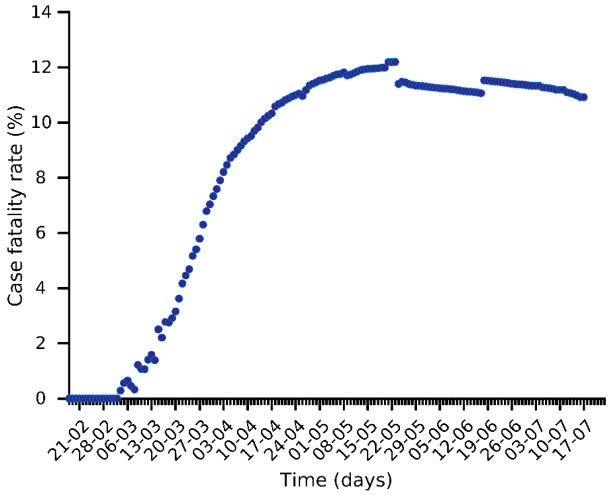


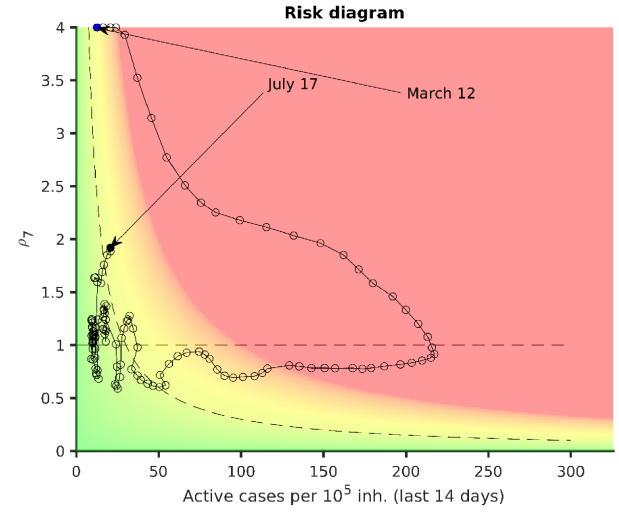


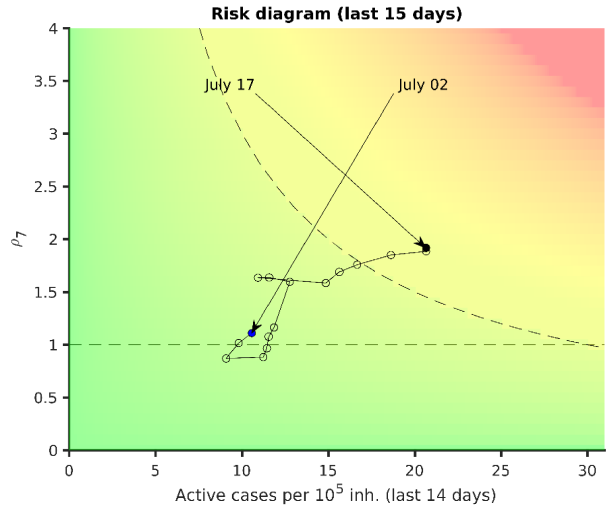




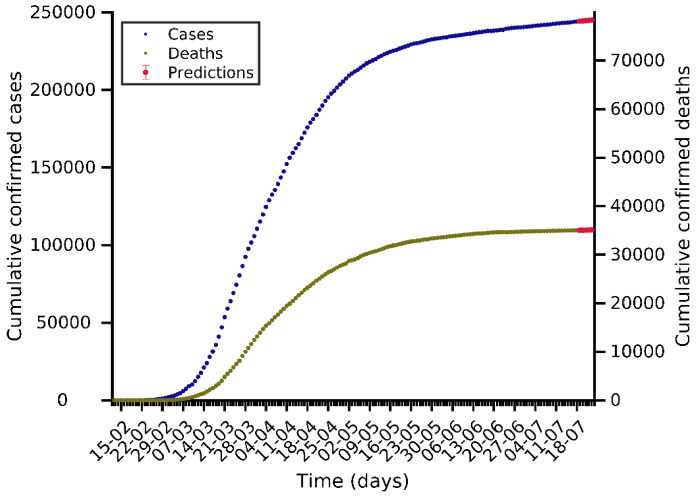


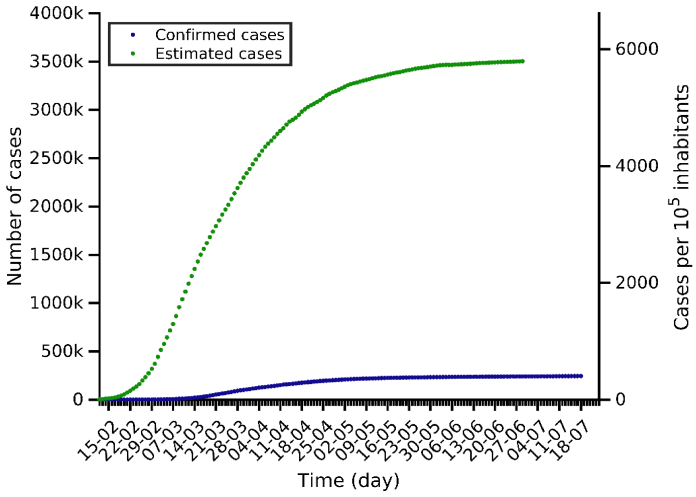


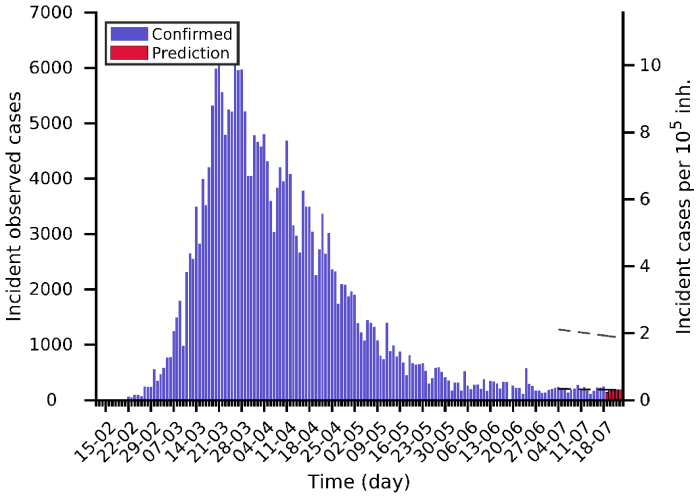


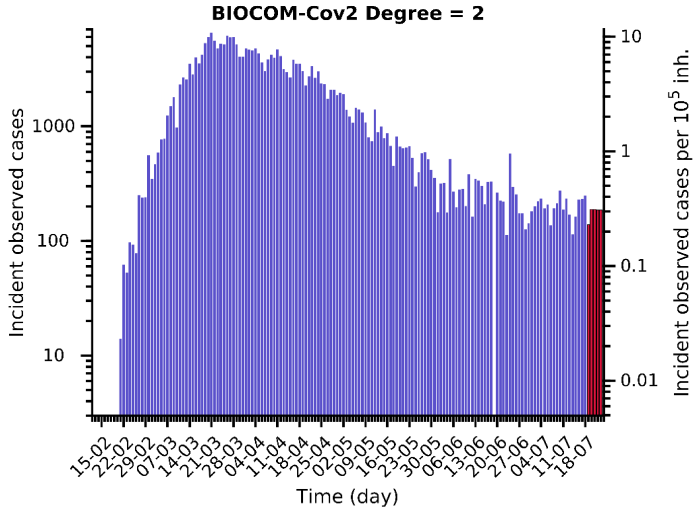


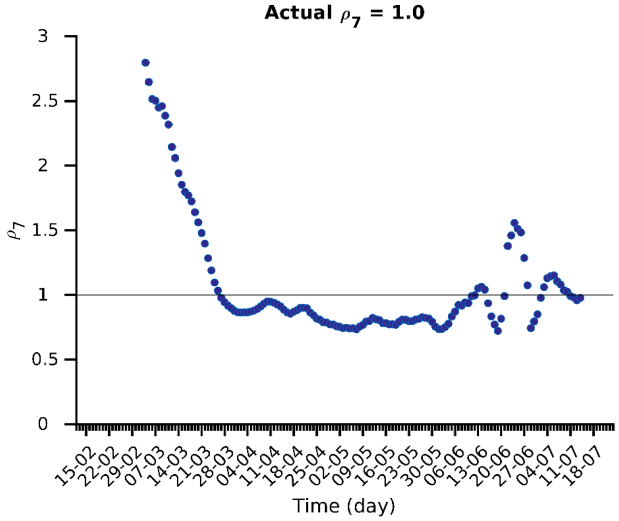
Italy 18-07-2020. Pop: 60.5M. Cumulative incidence: 404/10⁵

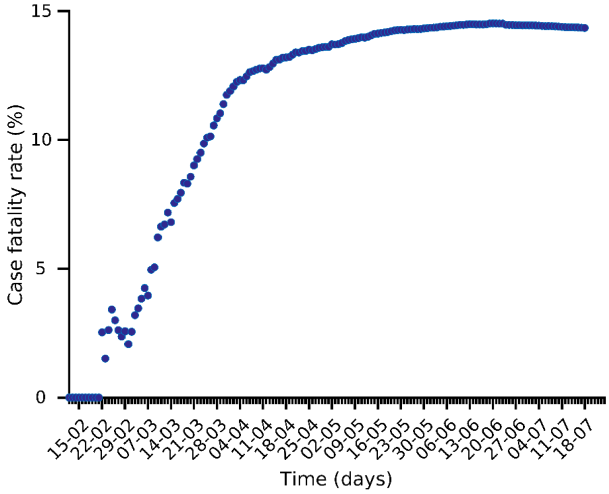


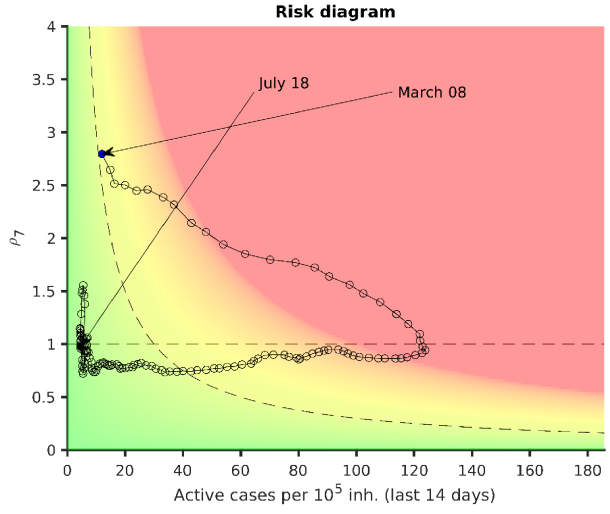


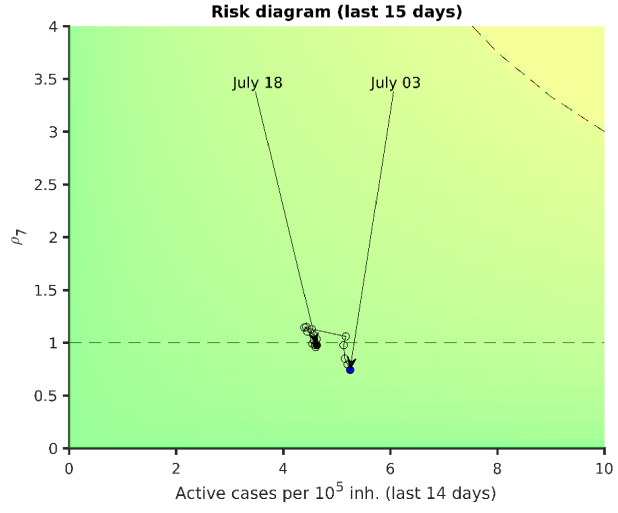




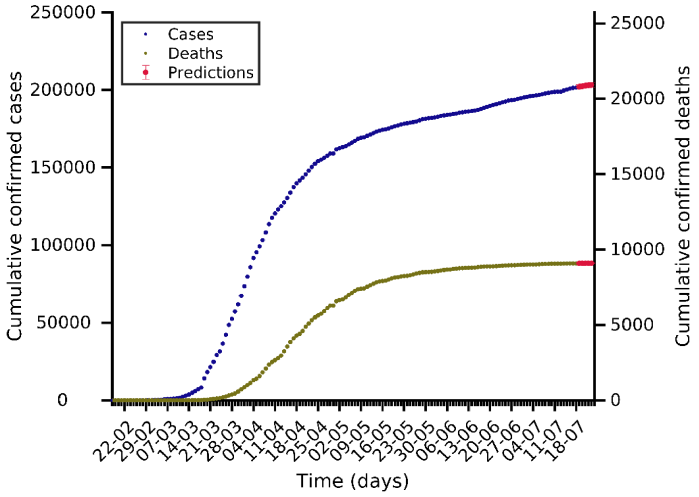


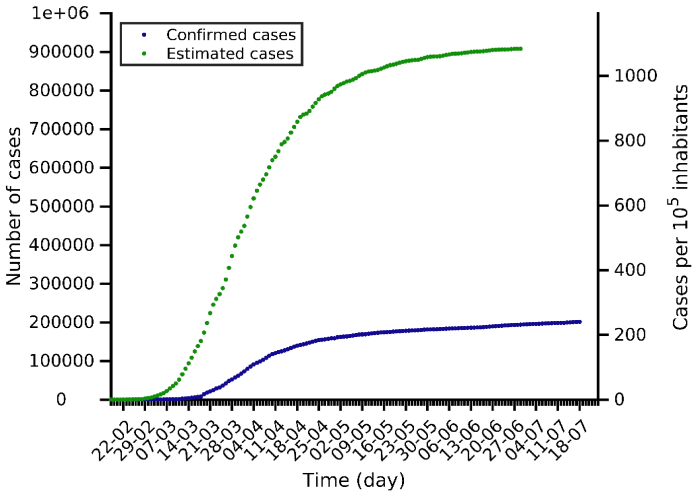


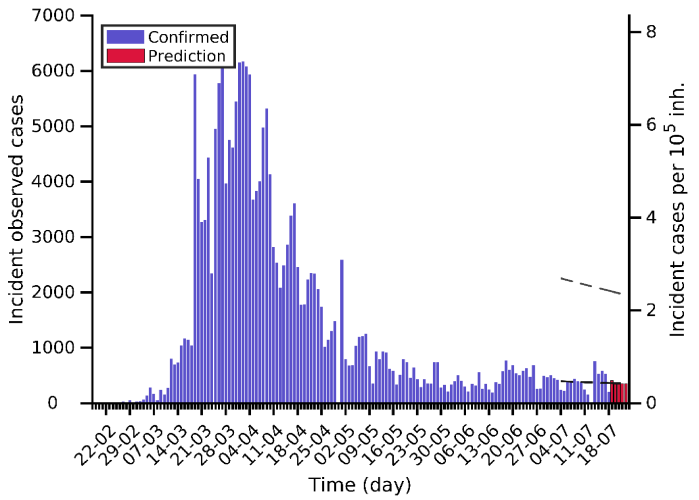


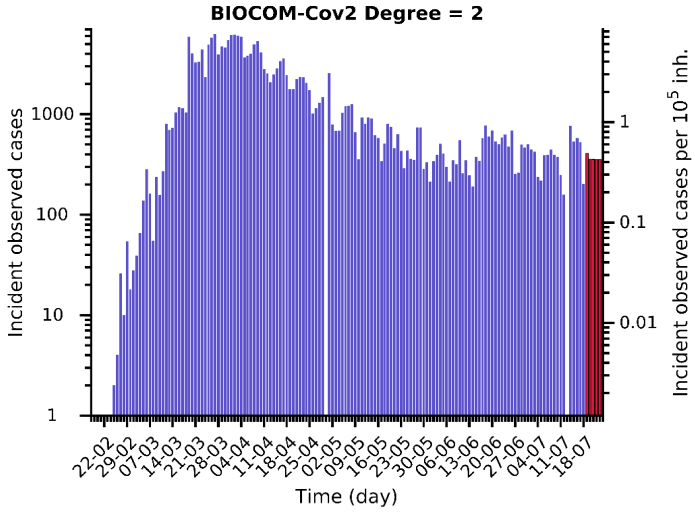


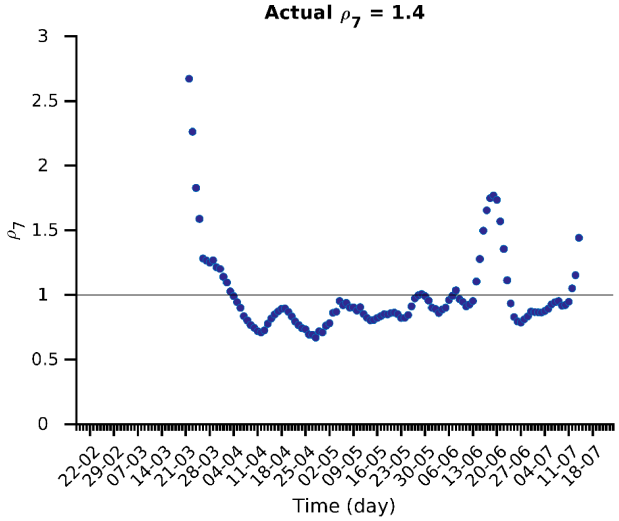
Germany 18-07-2020. Pop: 83.8M. Cumulative incidence: 241/10⁵

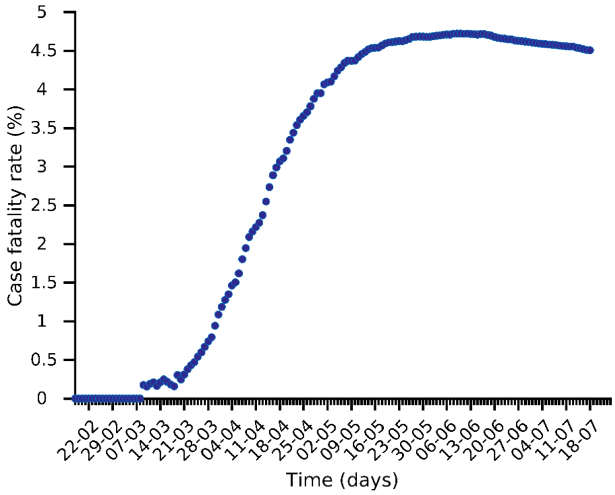


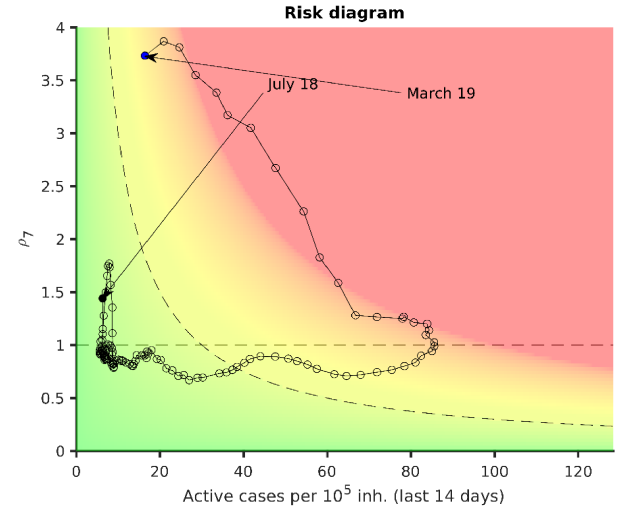


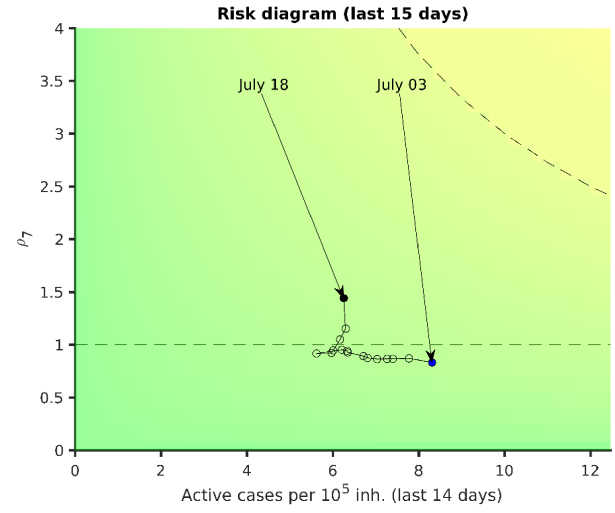




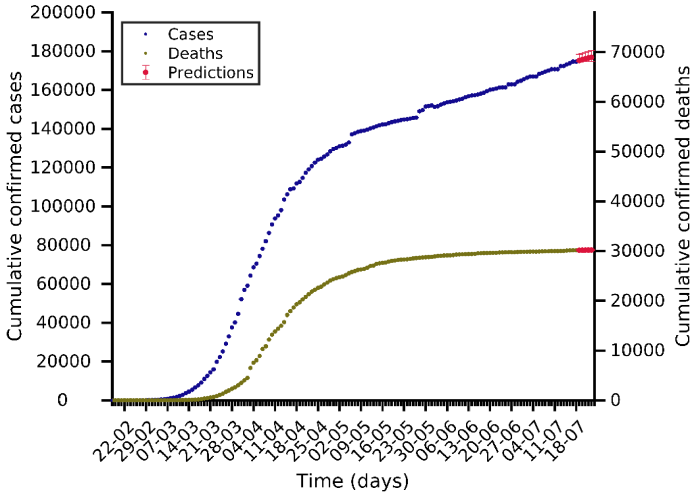


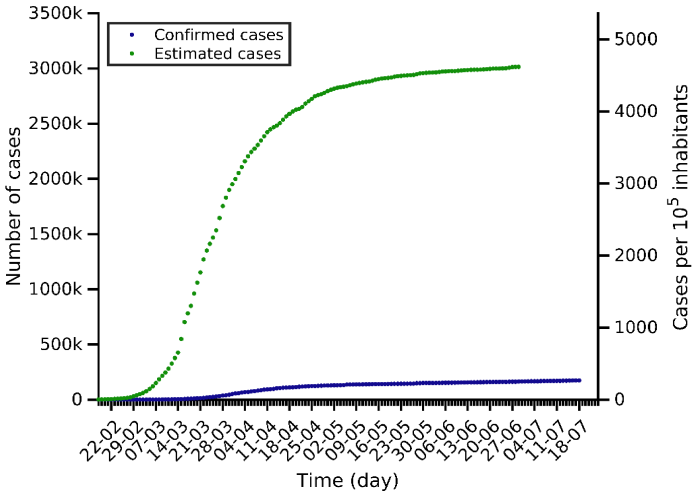


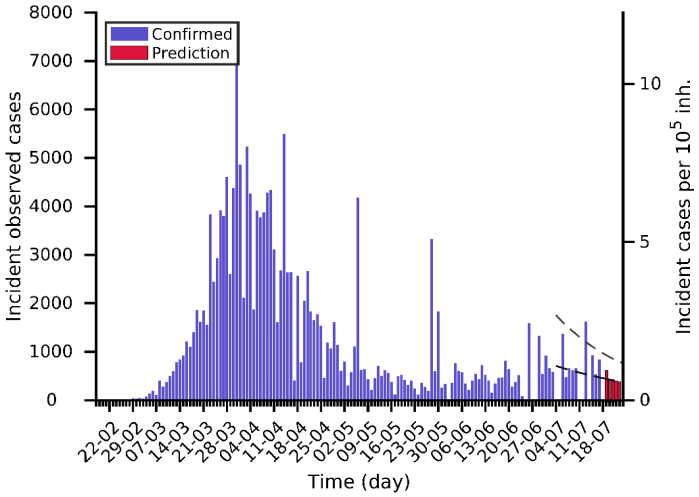


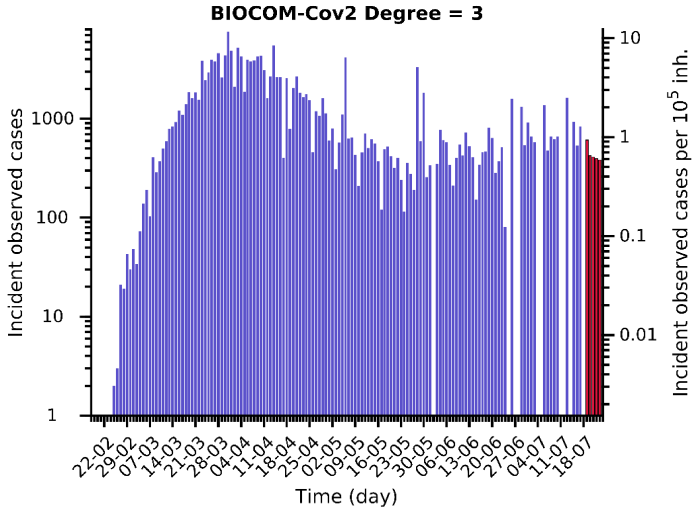


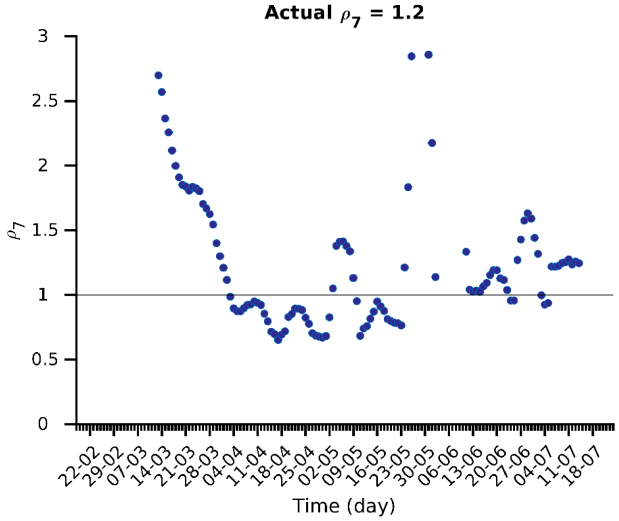
France 18-07-2020. Pop: 65.3M. Cumulative incidence: 268/10⁵

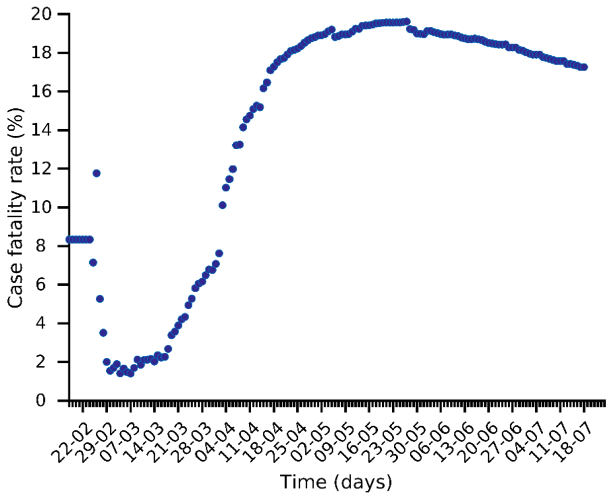


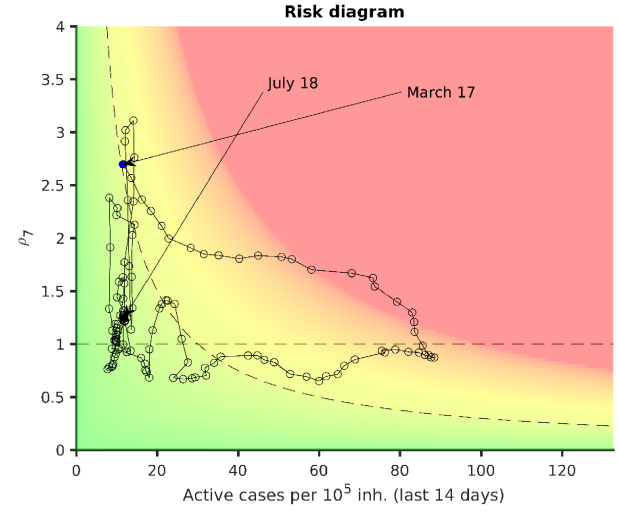


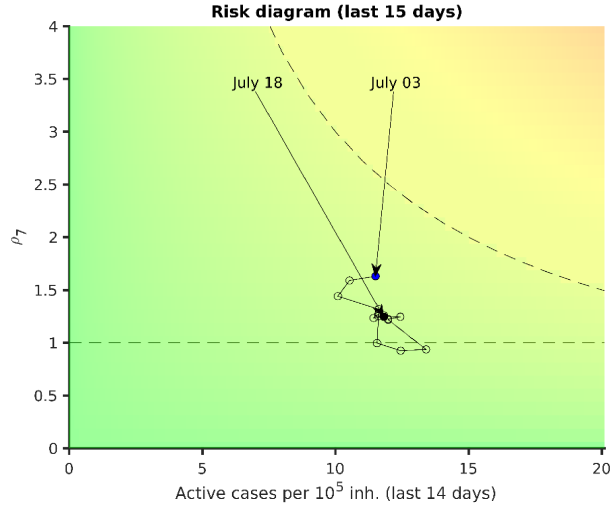




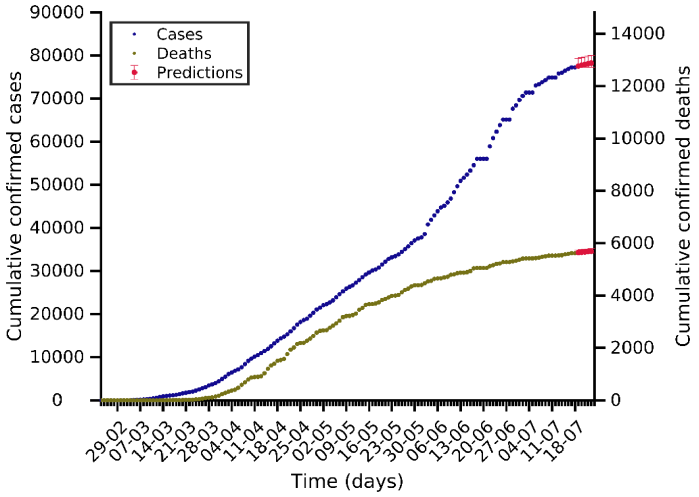


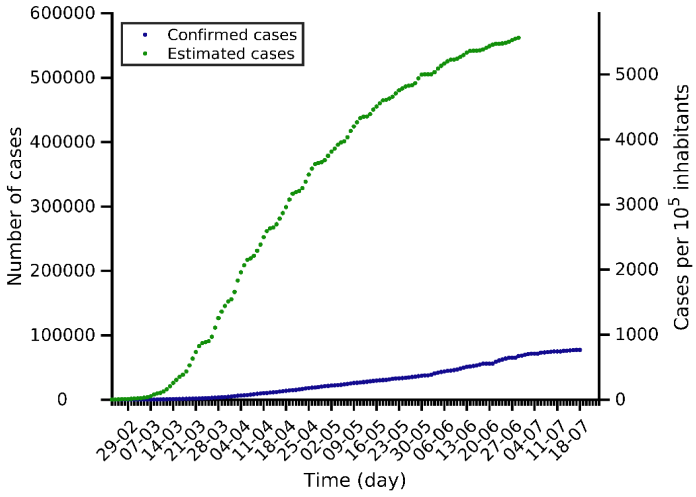


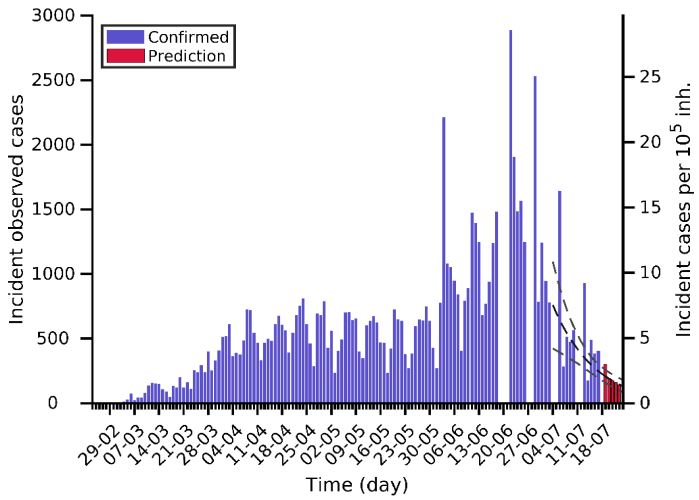


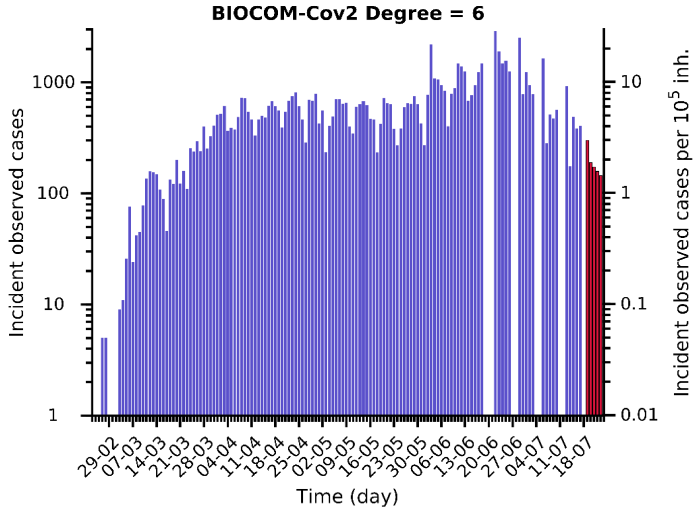


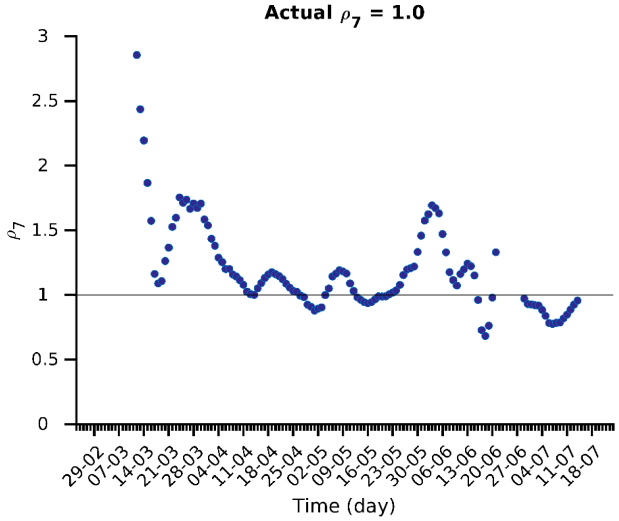
Sweden 18-07-2020. Pop: 10.1M. Cumulative incidence: 765/10⁵

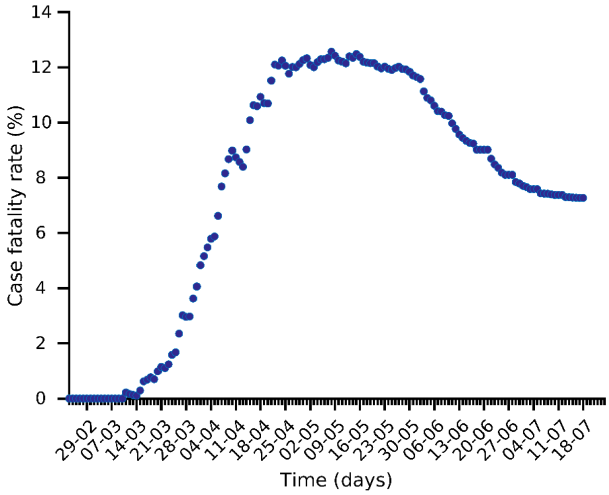


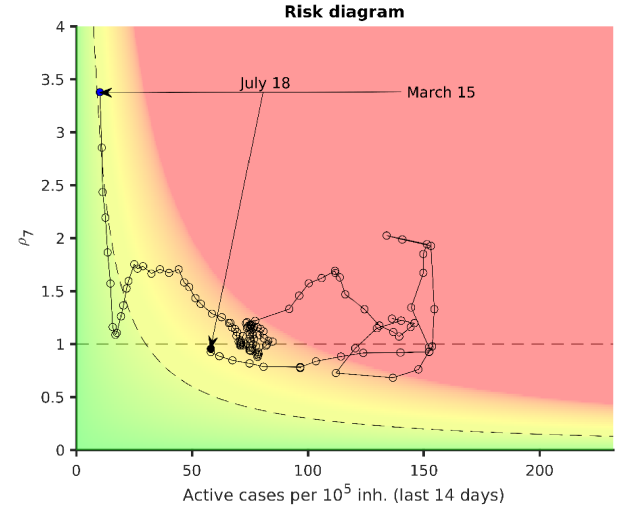


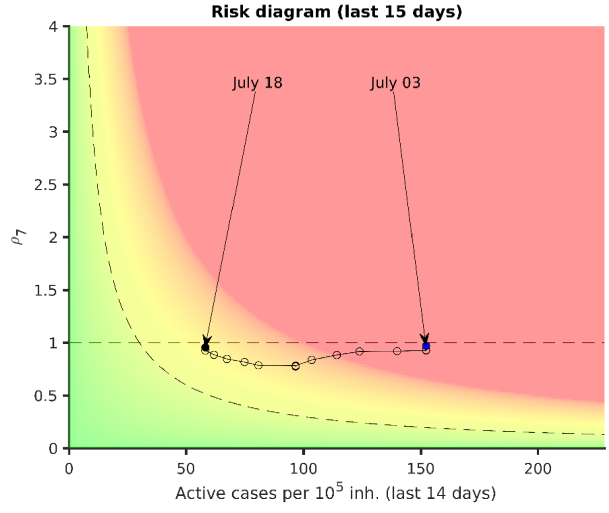




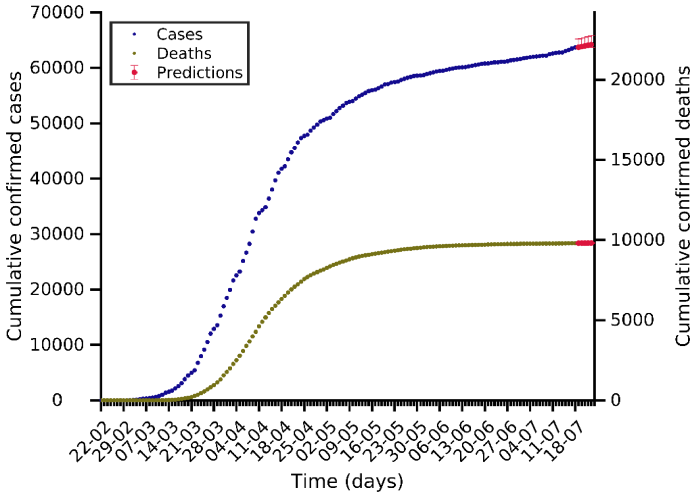


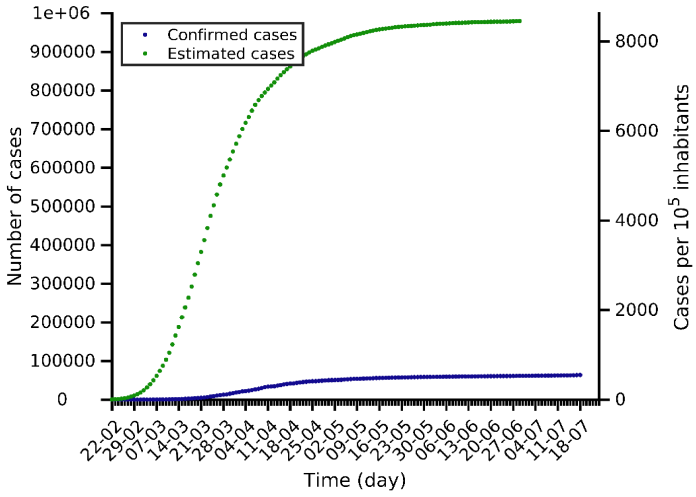


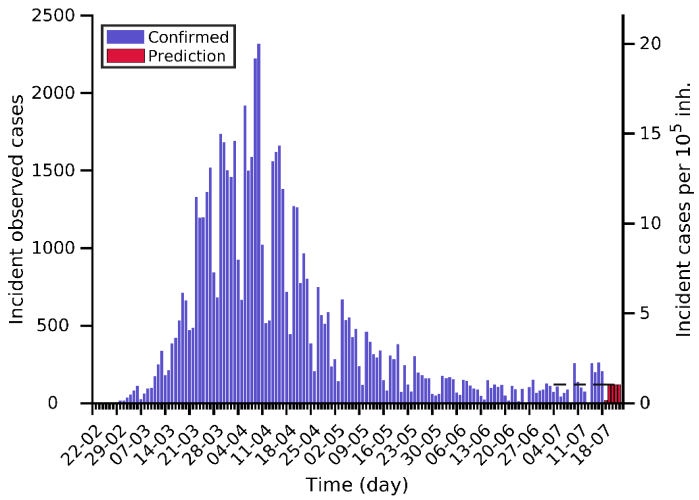


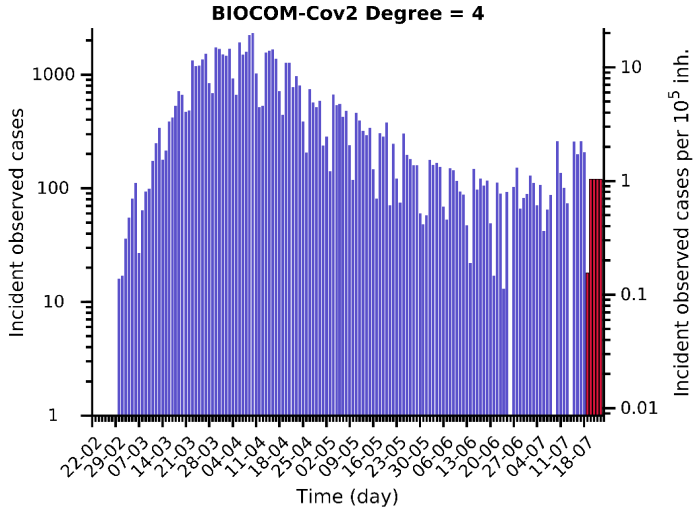


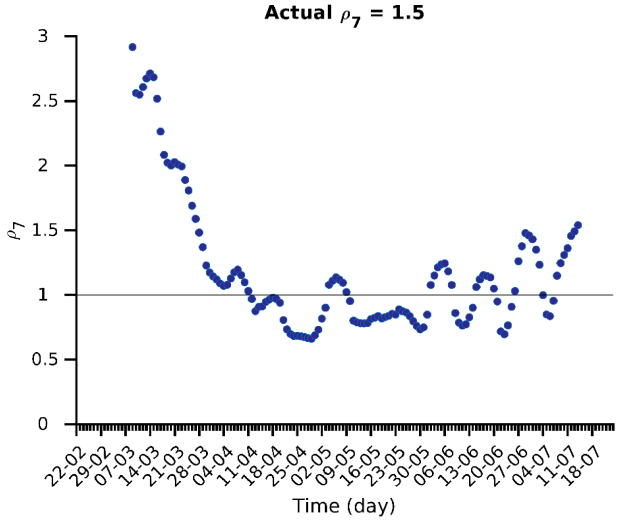
Belgium 18-07-2020. Pop: 11.6M. Cumulative incidence: 550/10^5

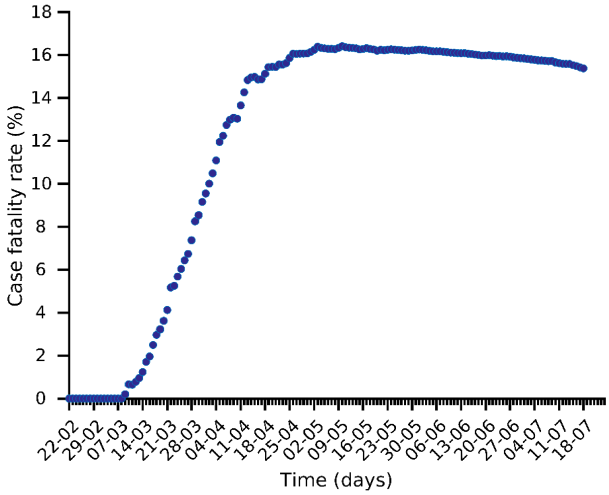


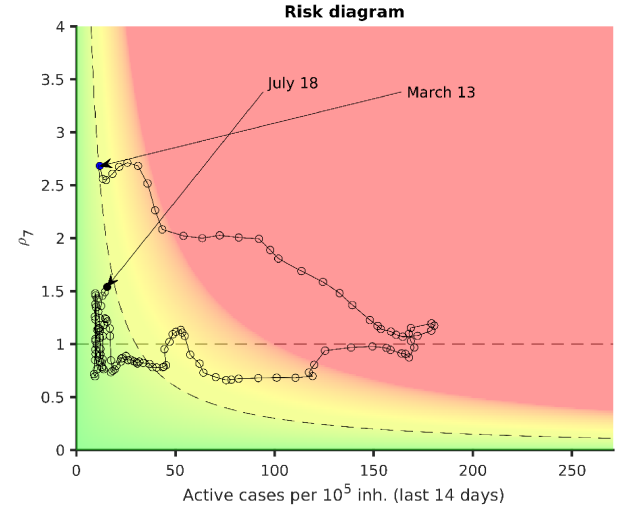


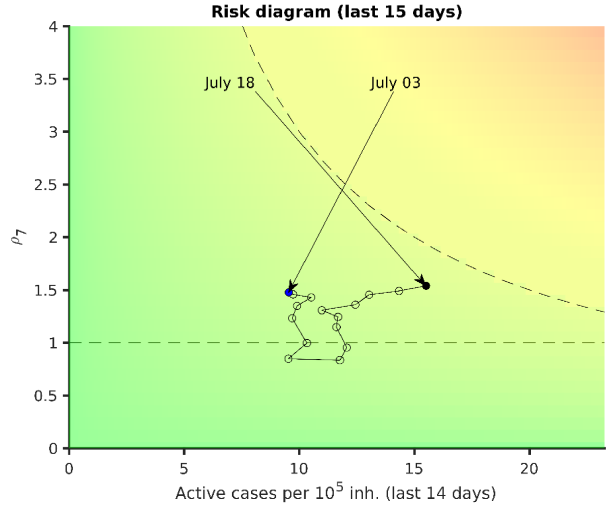




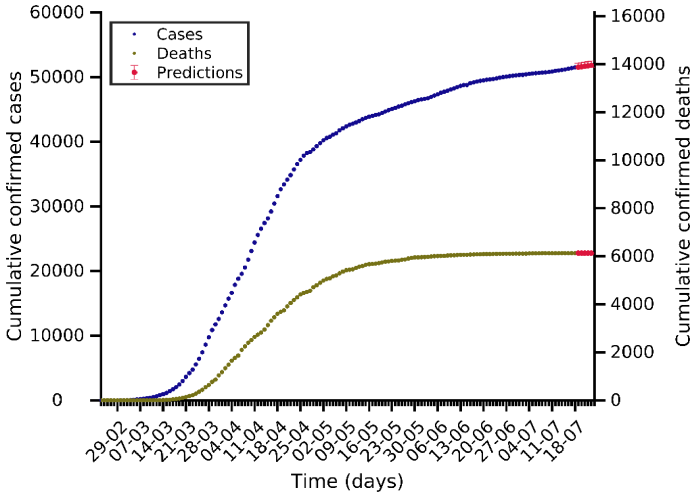


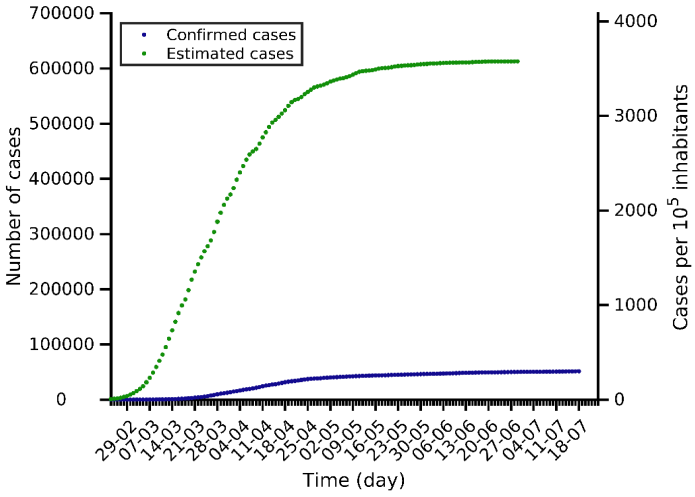


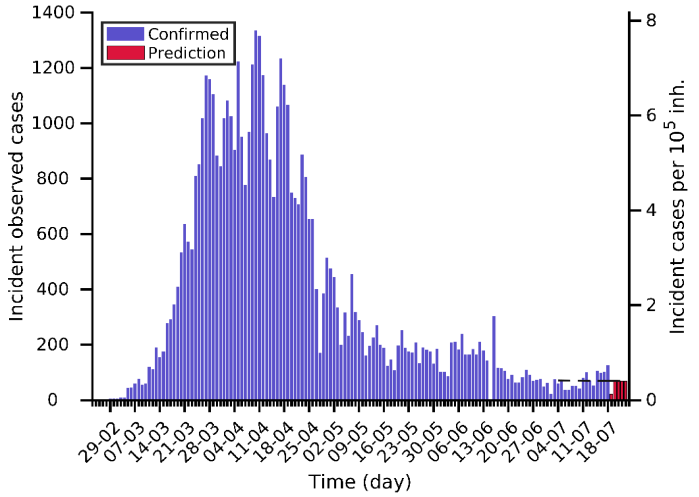


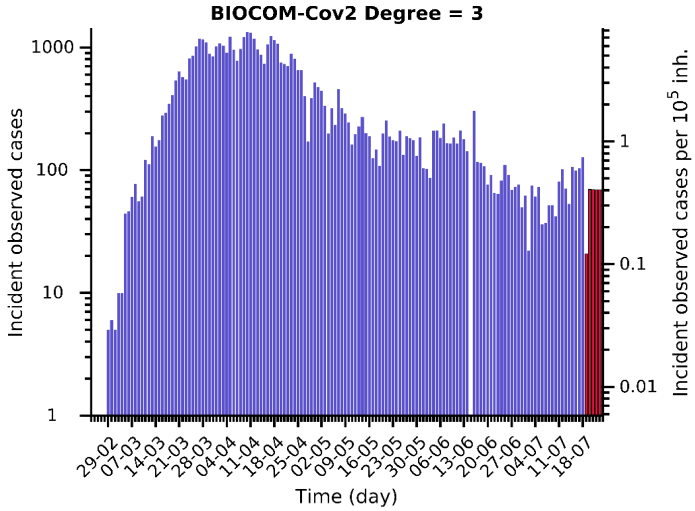


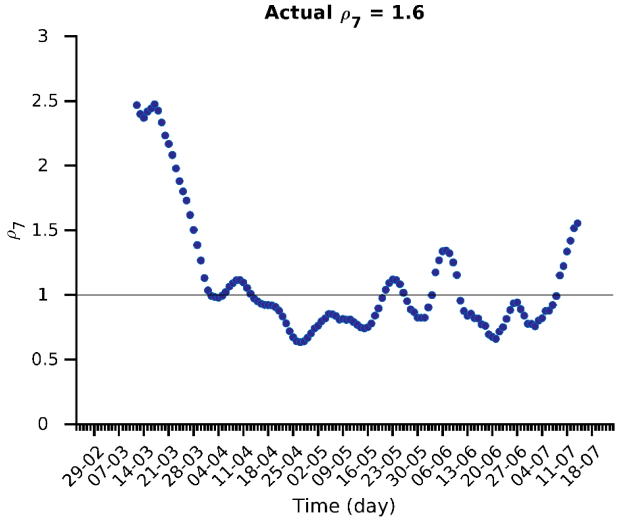
Netherlands 18-07-2020. Pop: 17.1M. Cumulative incidence: 301/10⁵

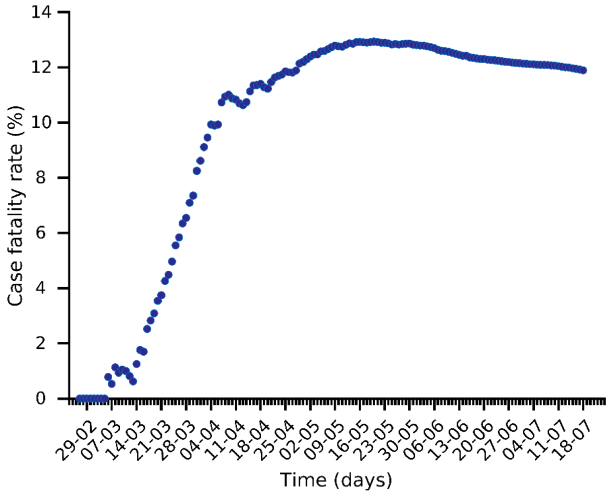


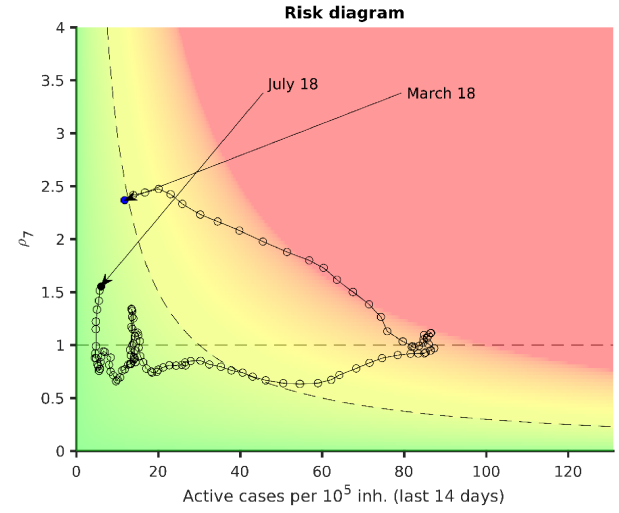


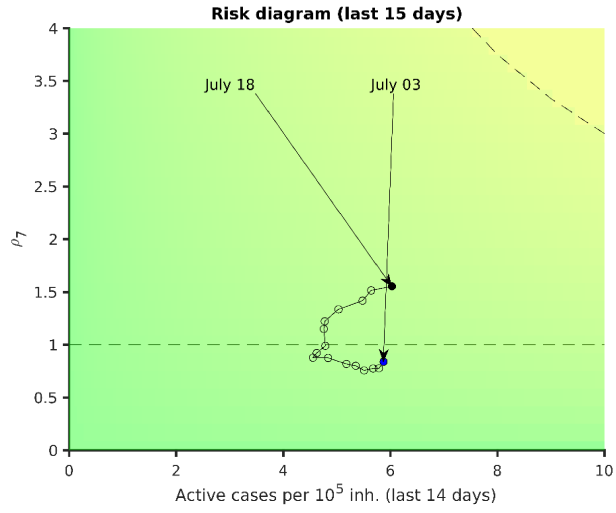




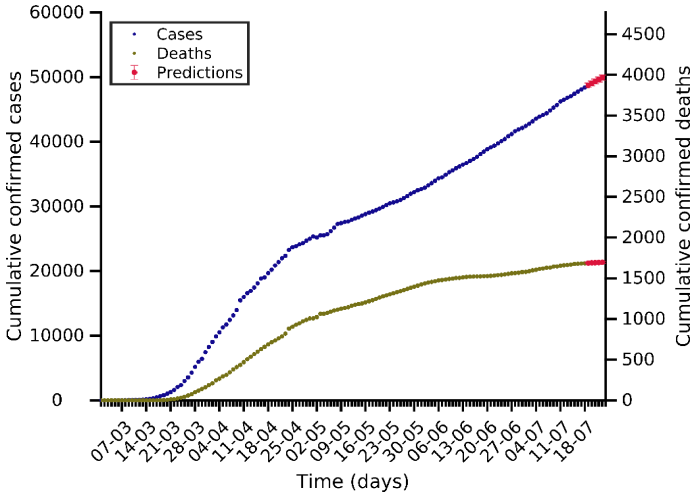


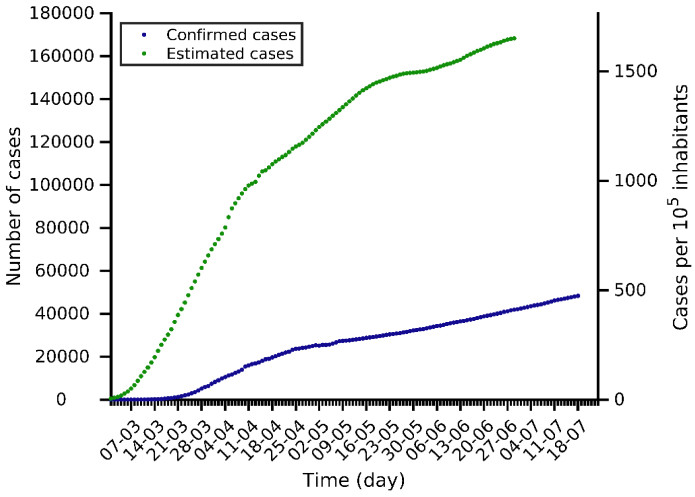


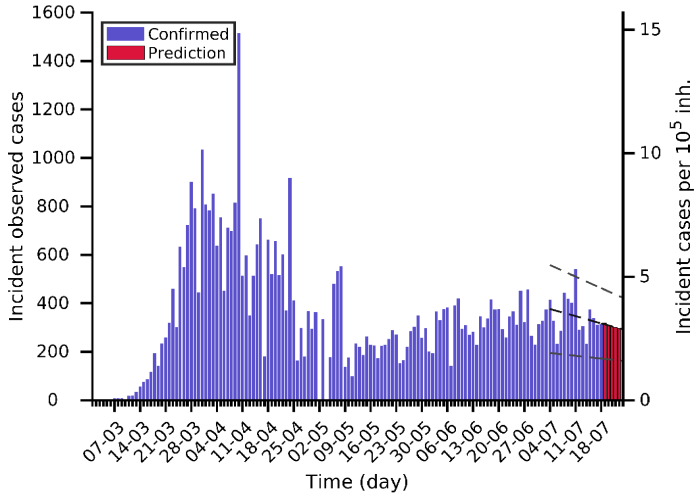


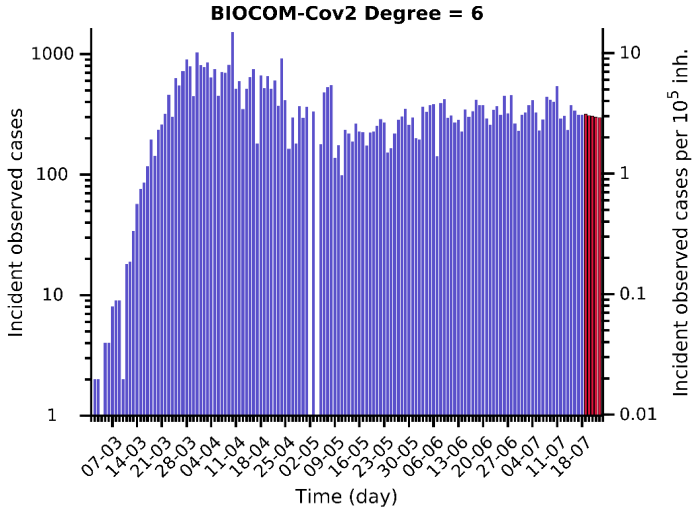


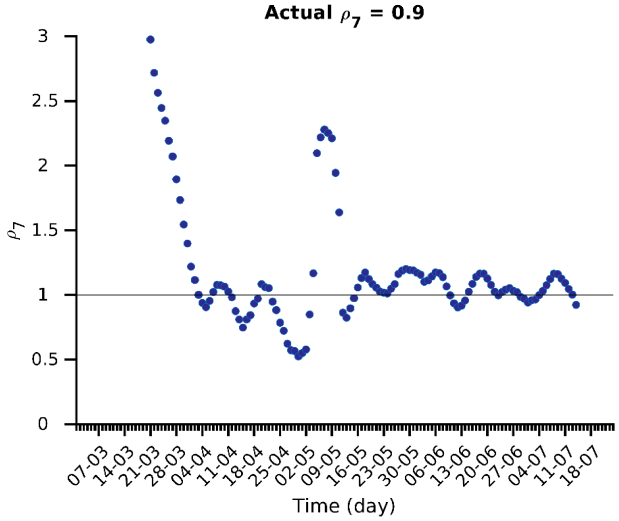
Portugal 18-07-2020. Pop: 10.2M. Cumulative incidence: 475/10⁵

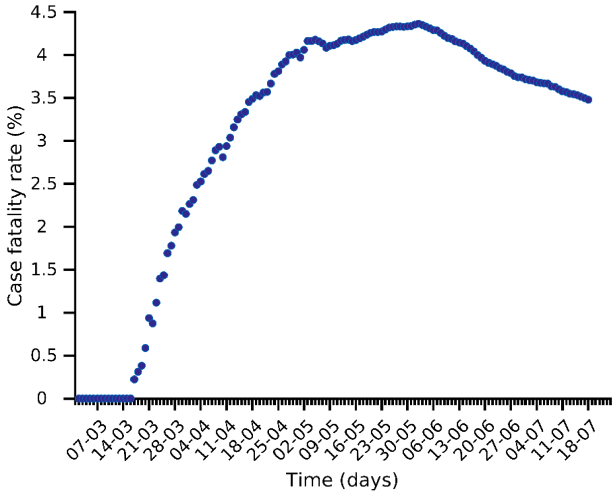


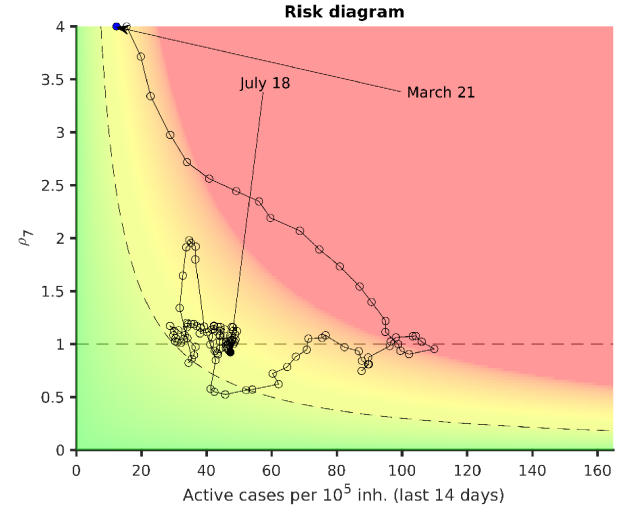


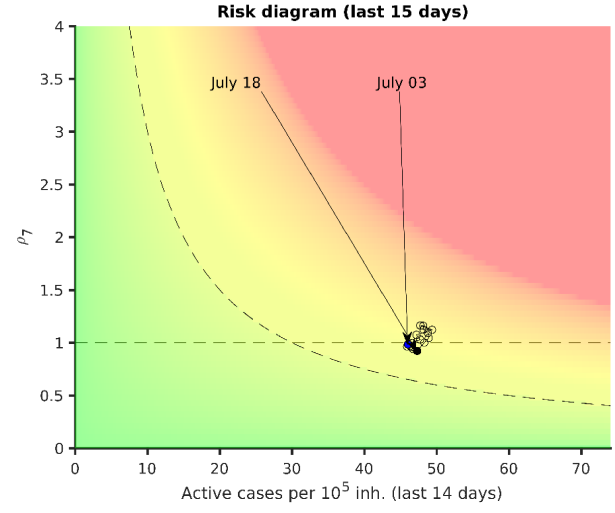




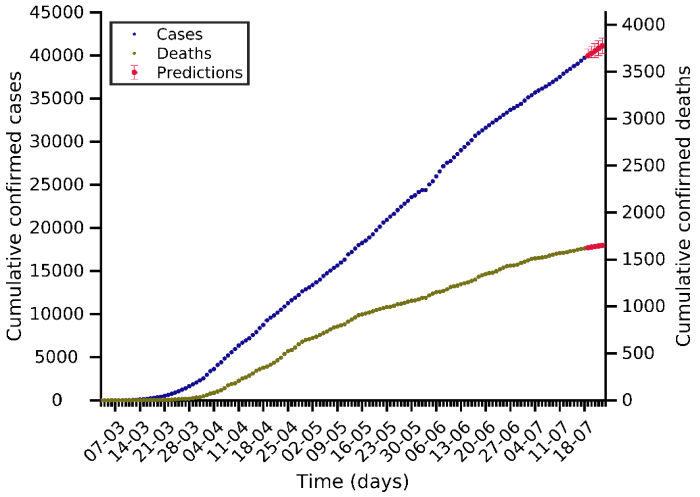


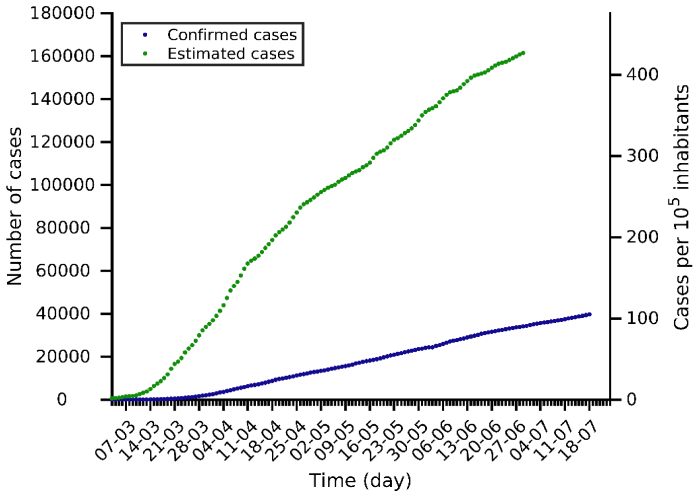


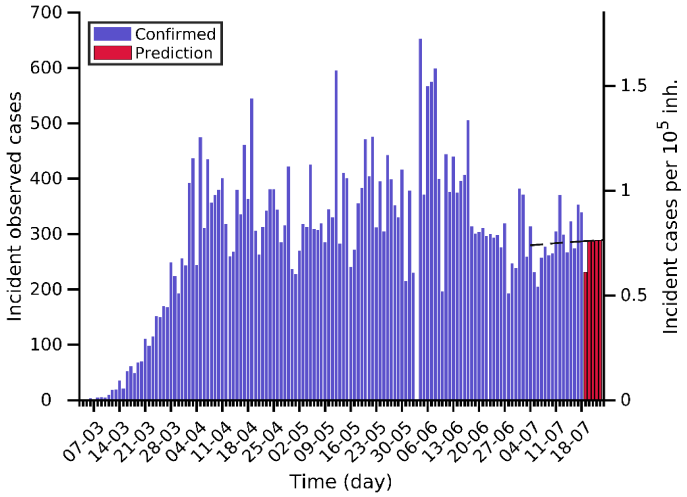


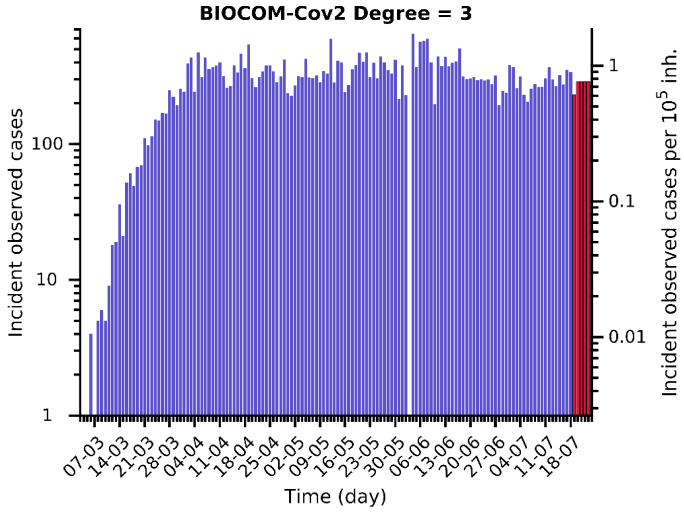


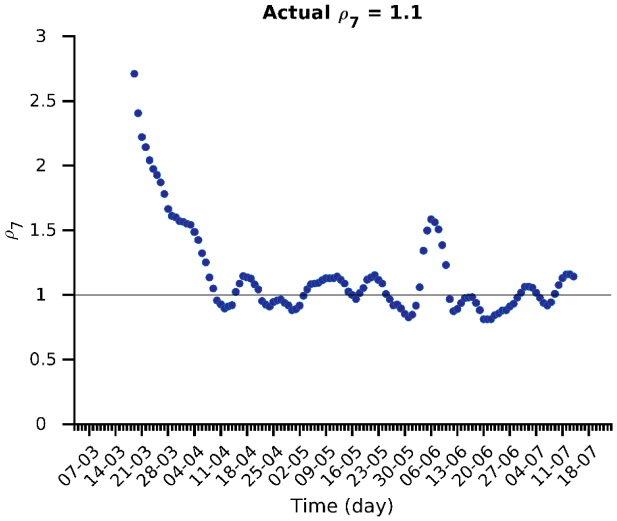
Poland 18-07-2020. Pop: 37.8M. Cumulative incidence: $105/10^5$

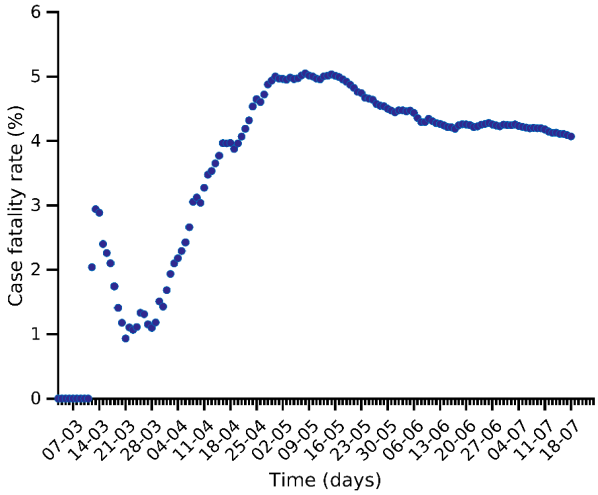


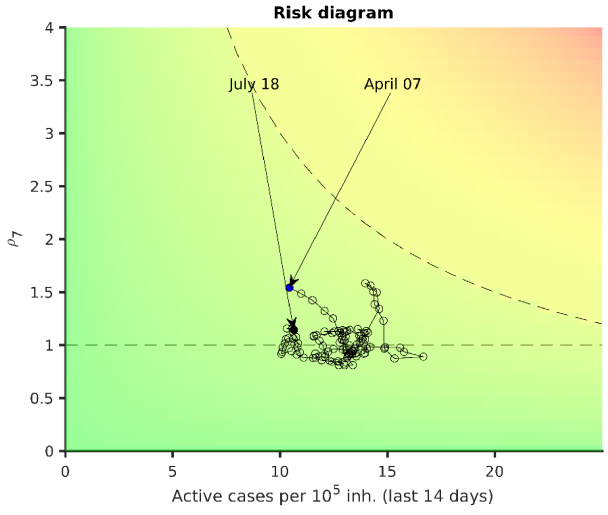


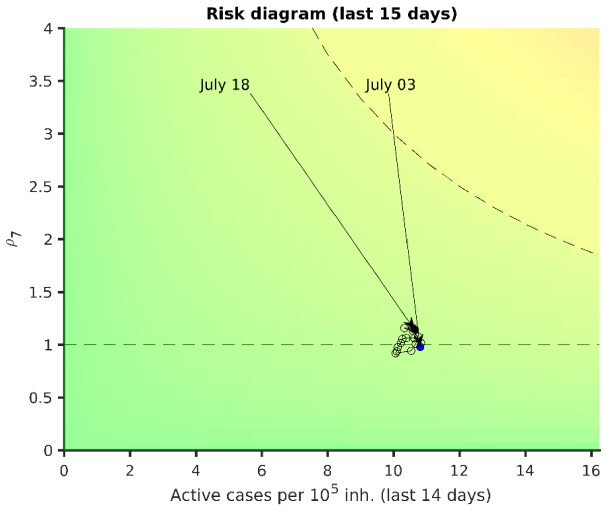




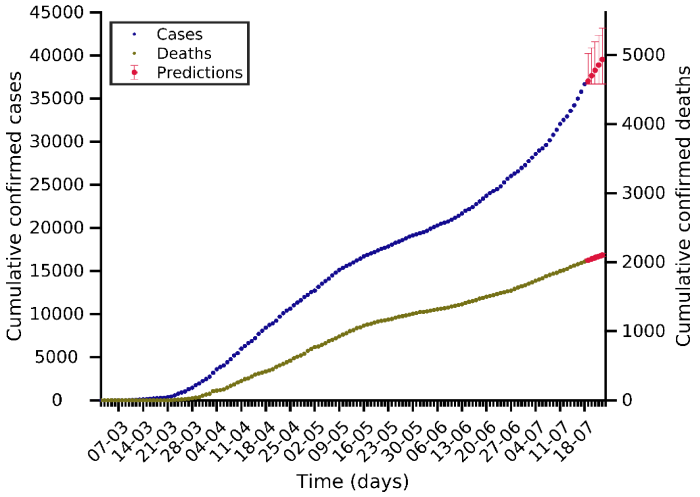


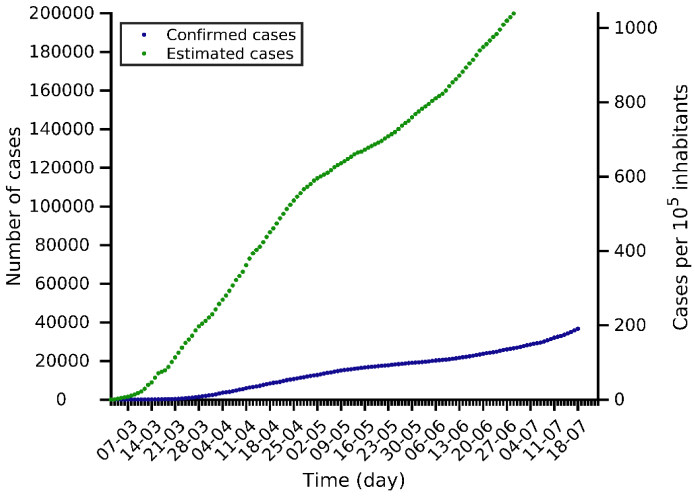


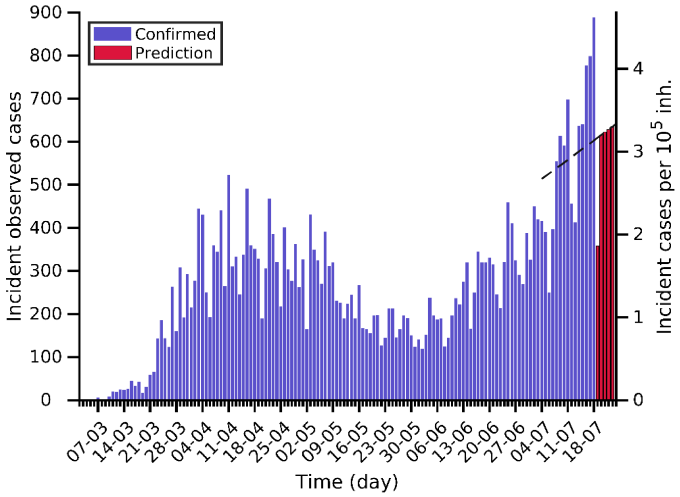


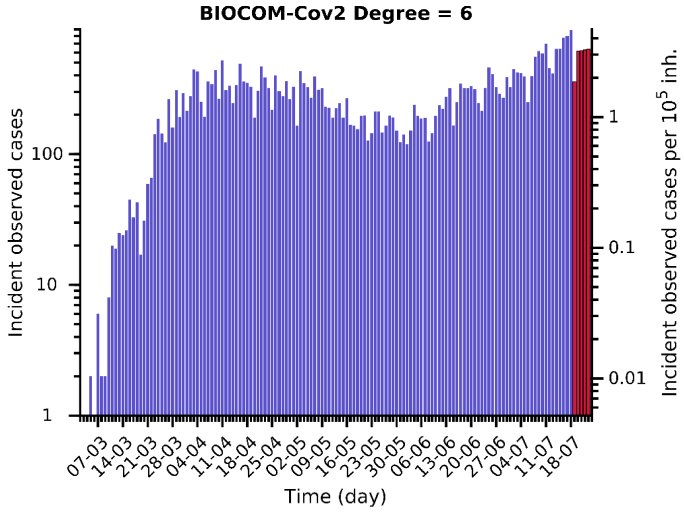


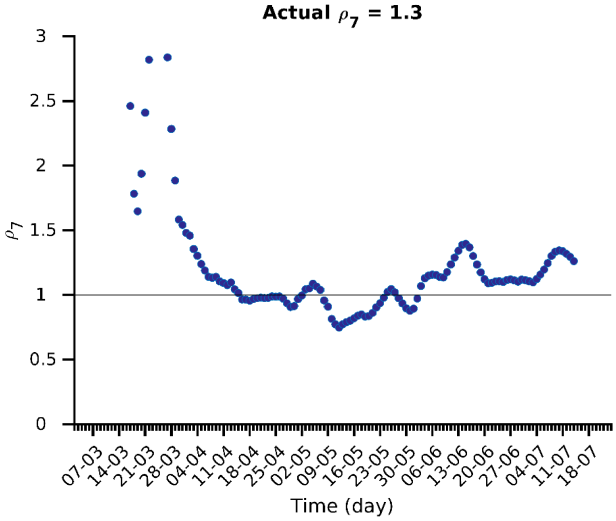
Romania 18-07-2020. Pop: 19.2M. Cumulative incidence: 191/10⁵

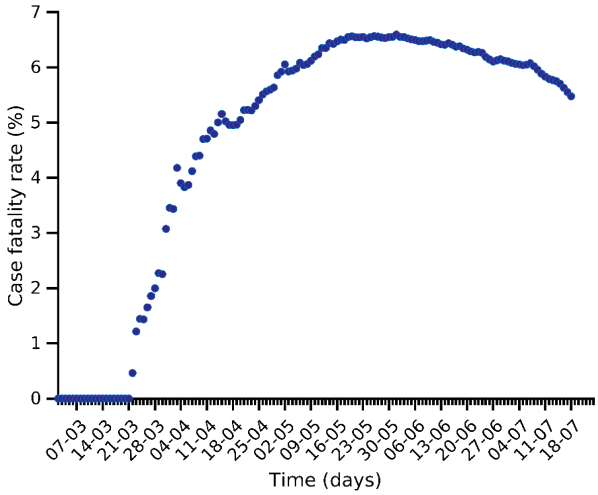


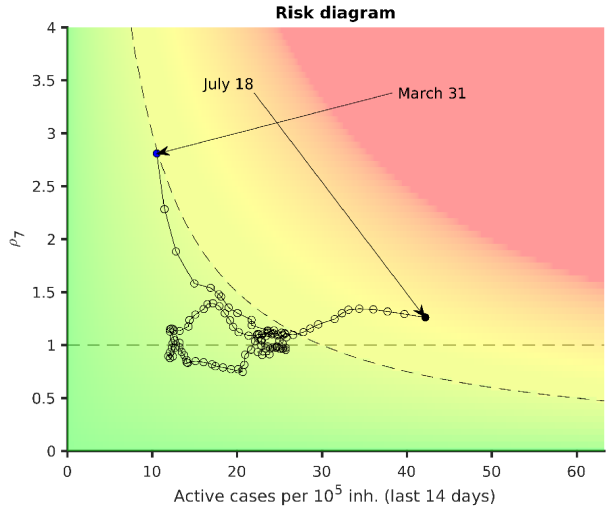


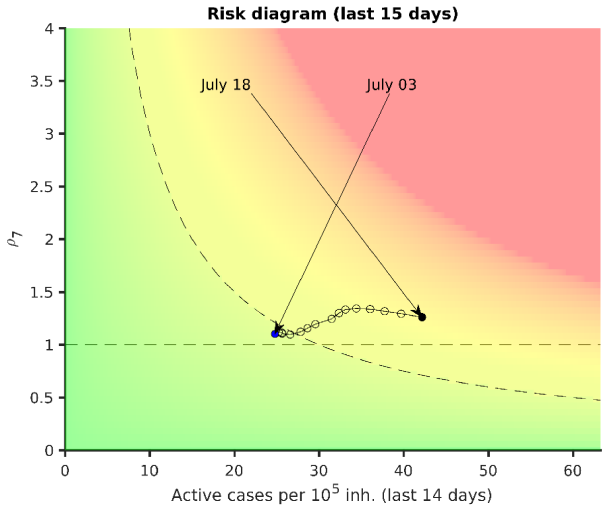




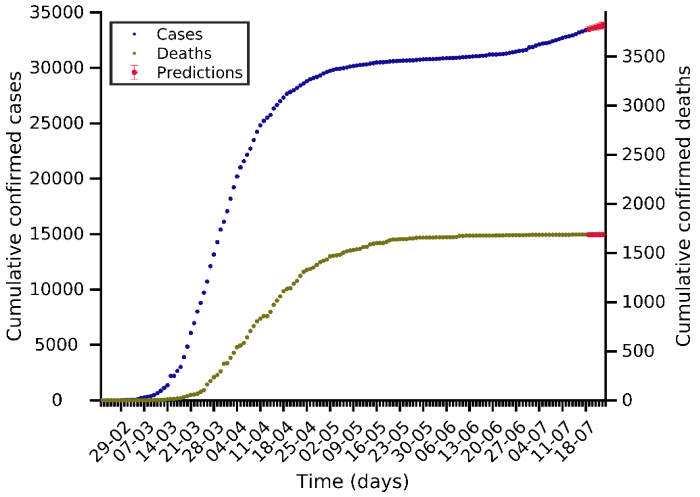


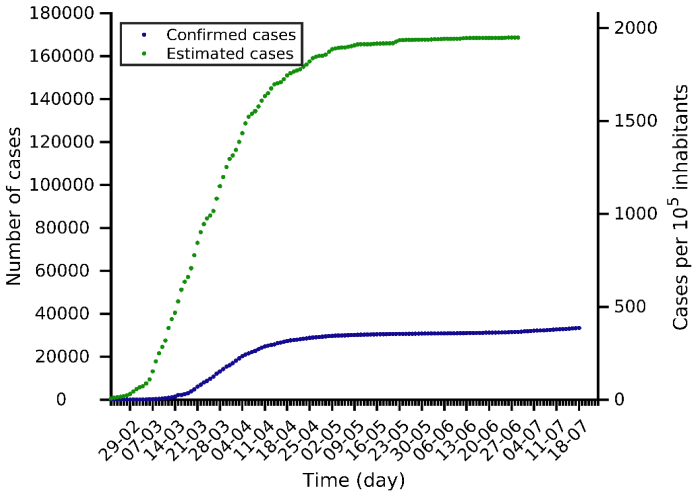


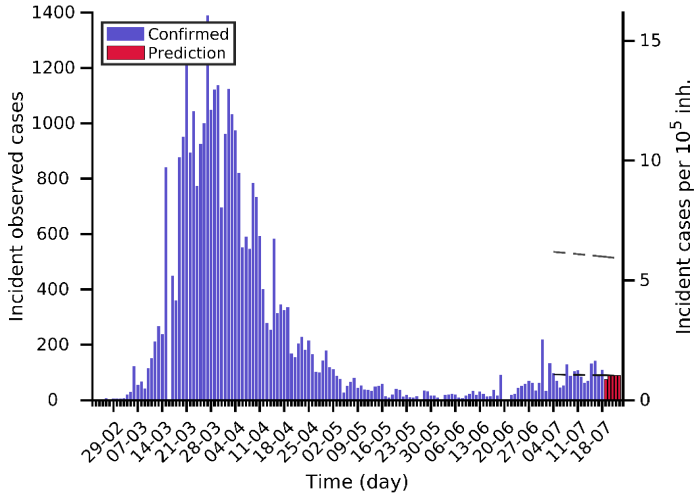


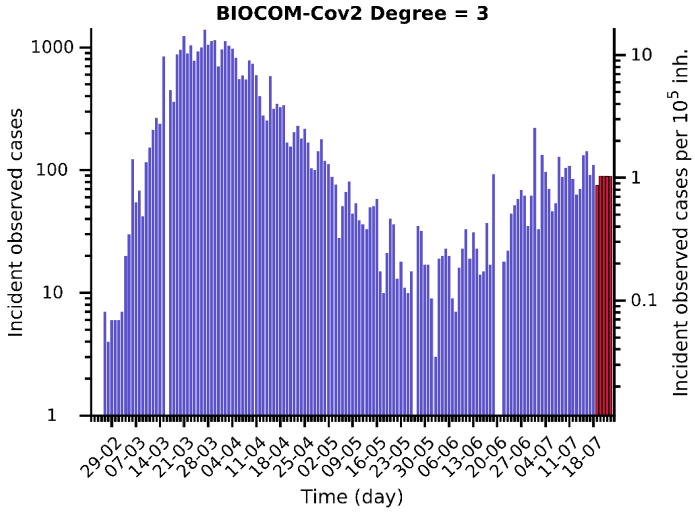


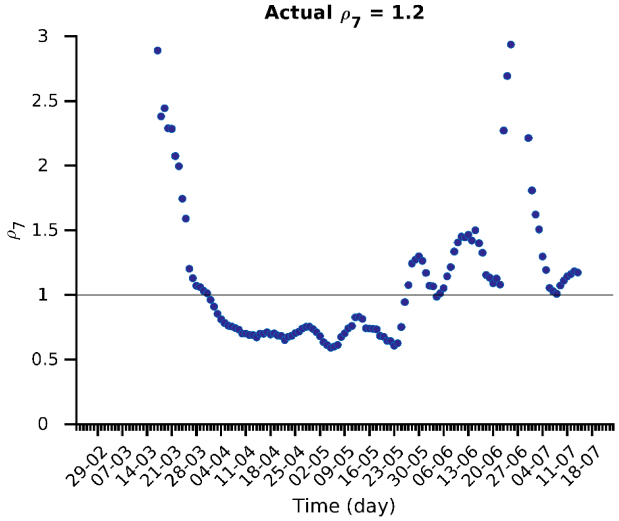
Switzerland 18-07-2020. Pop: 8.7M. Cumulative incidence: 386/10⁵

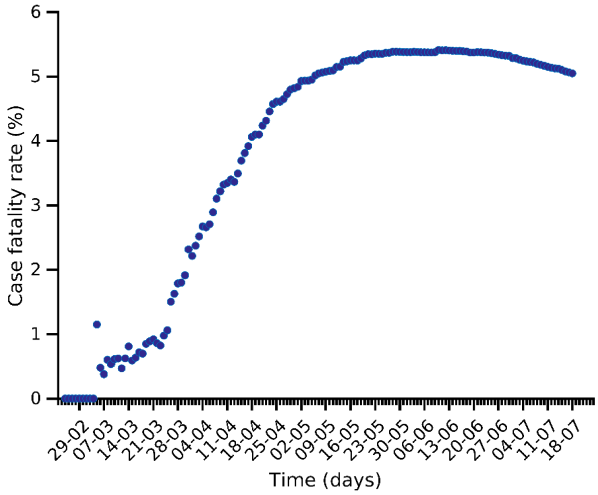


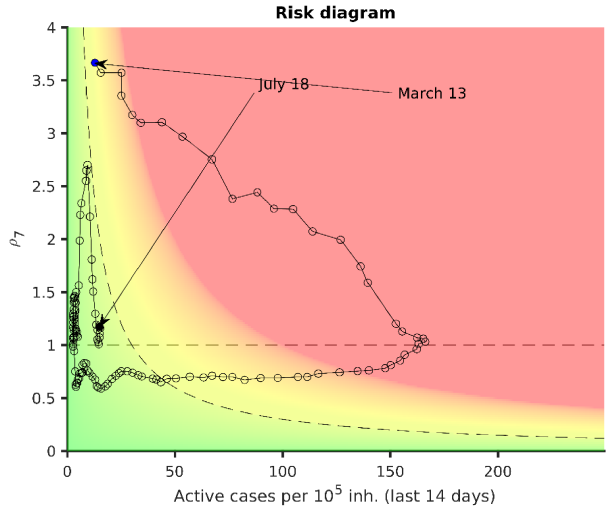


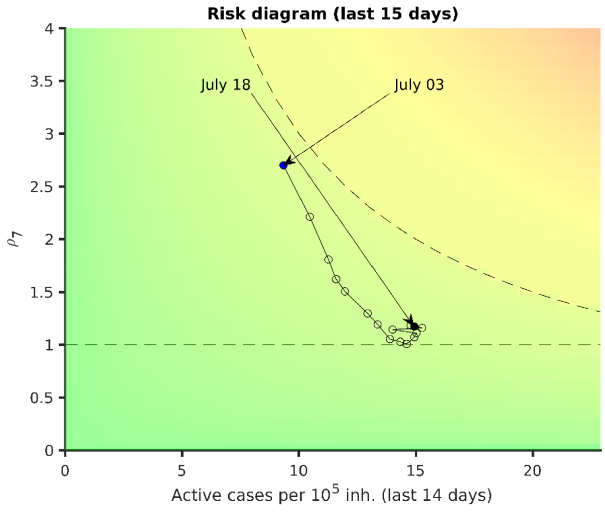




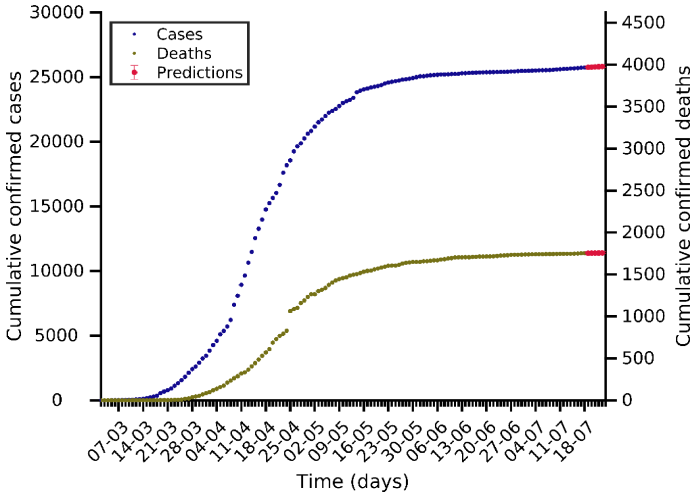


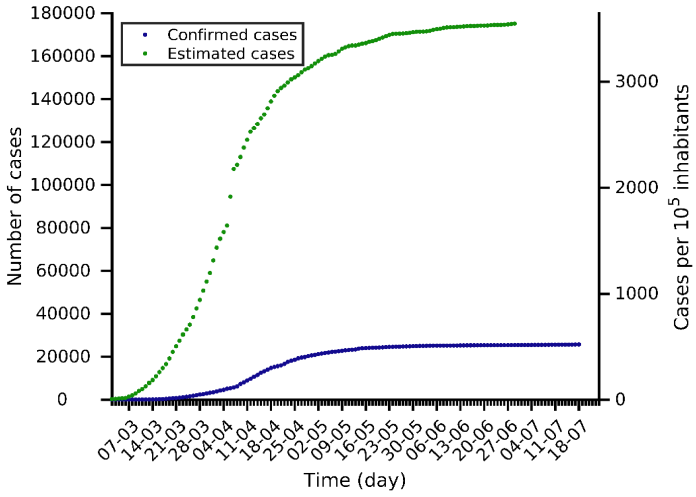


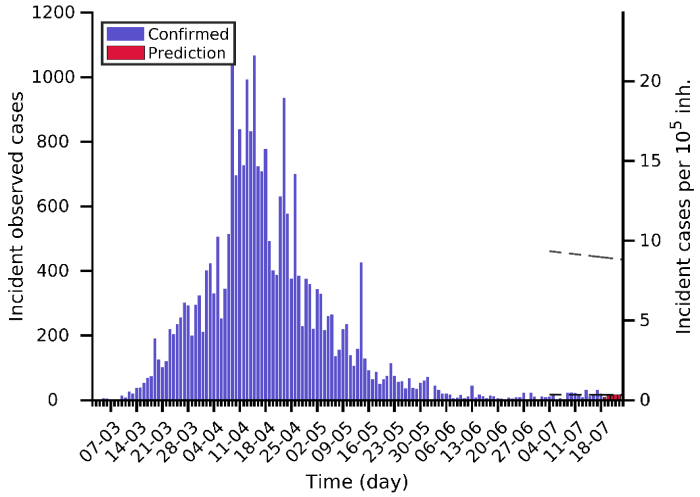


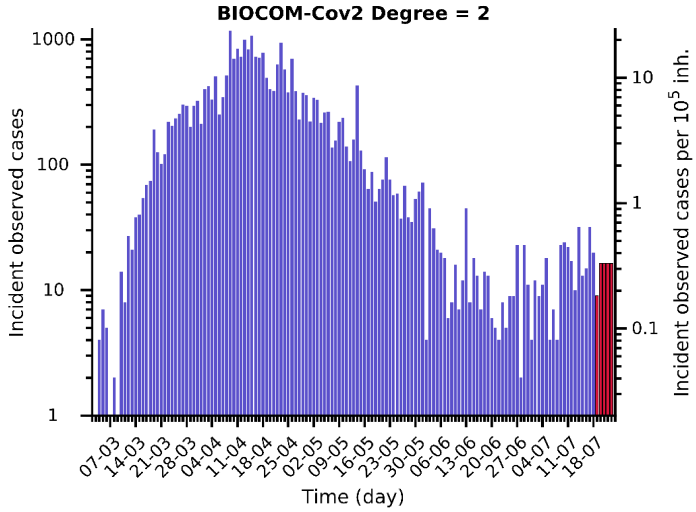


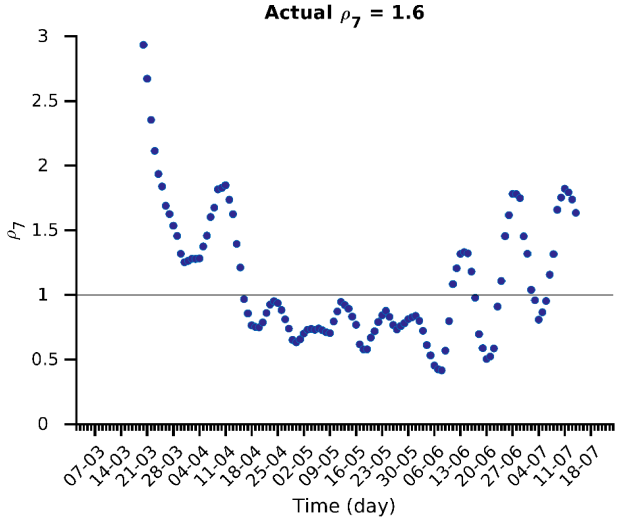
Ireland 18-07-2020. Pop: 4.9M. Cumulative incidence: 521/10⁵

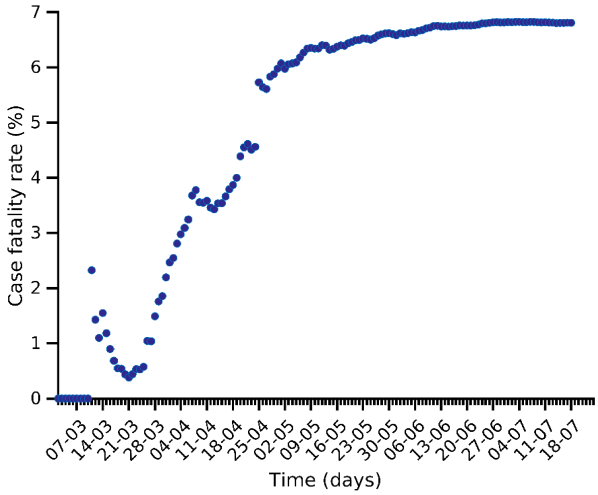


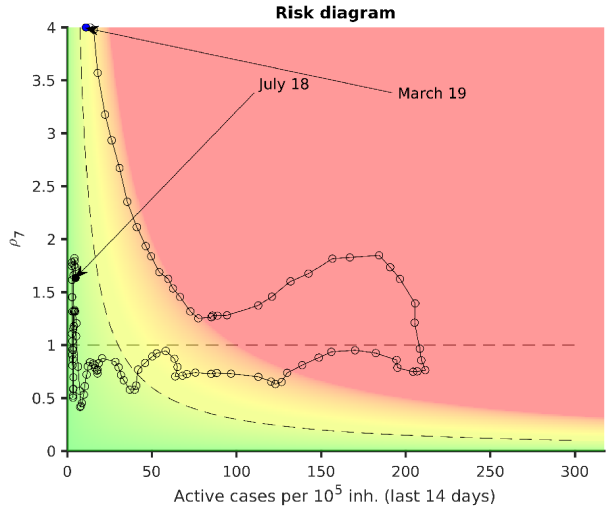


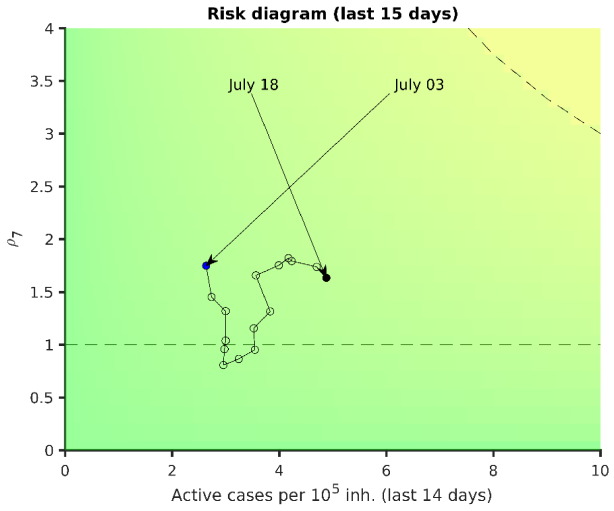




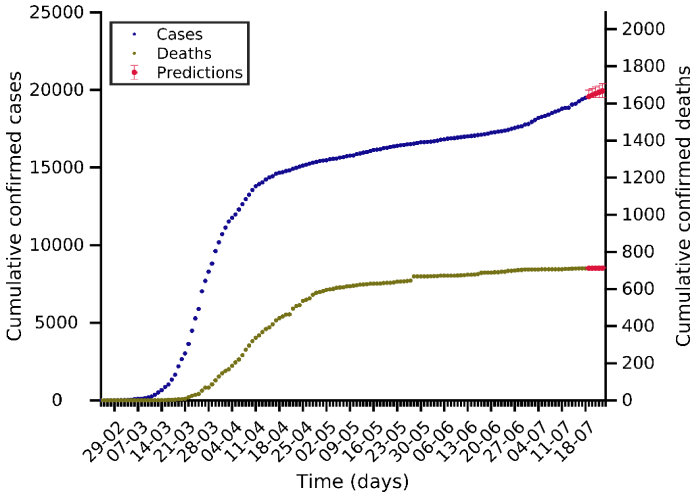


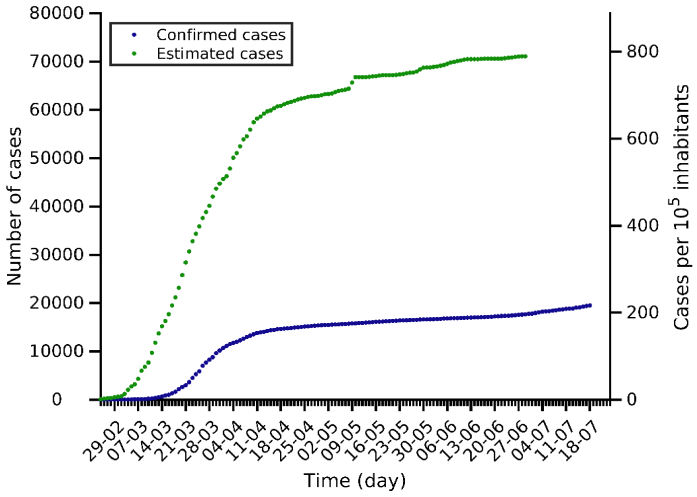


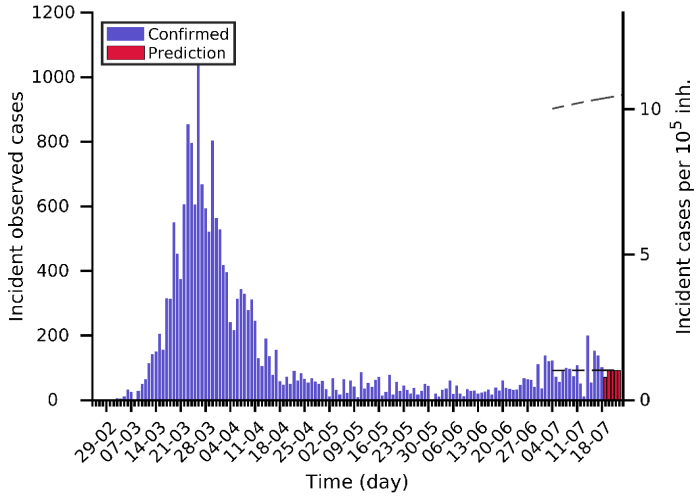


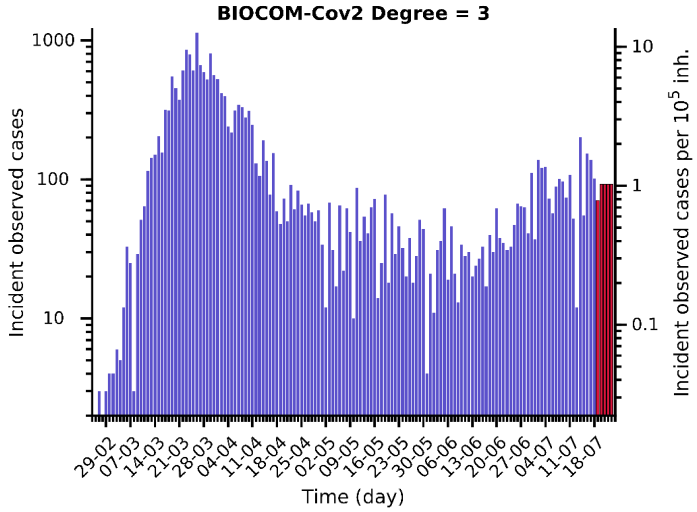


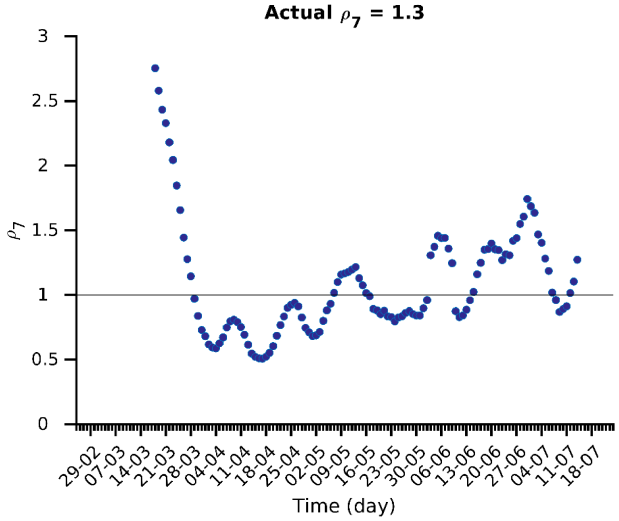
Austria 18-07-2020. Pop: 9.0M. Cumulative incidence: 217/10⁵

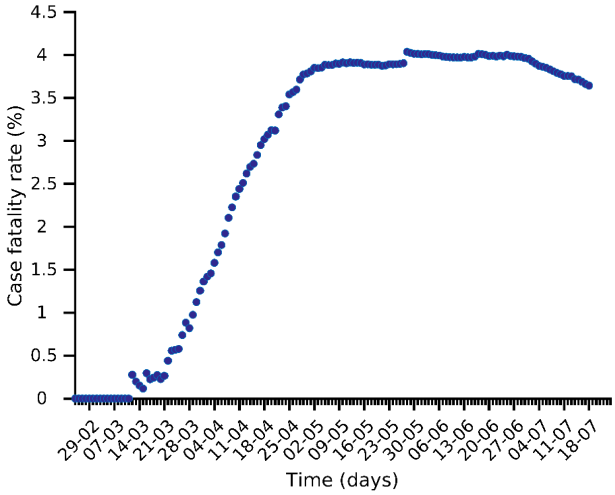


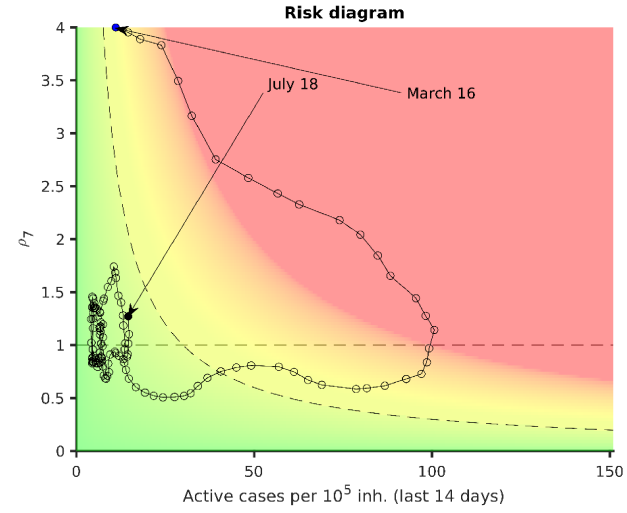


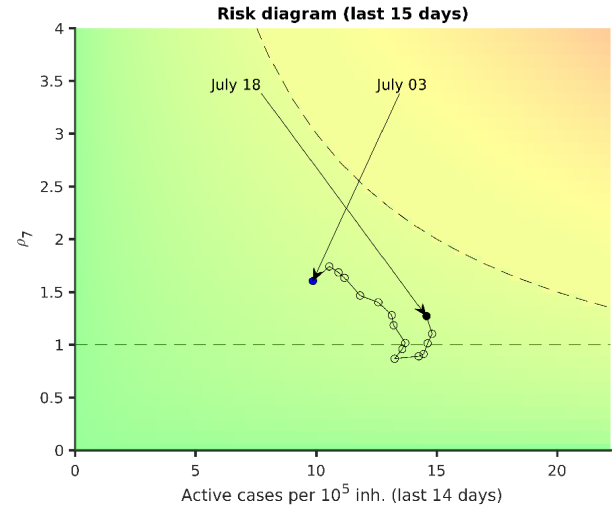




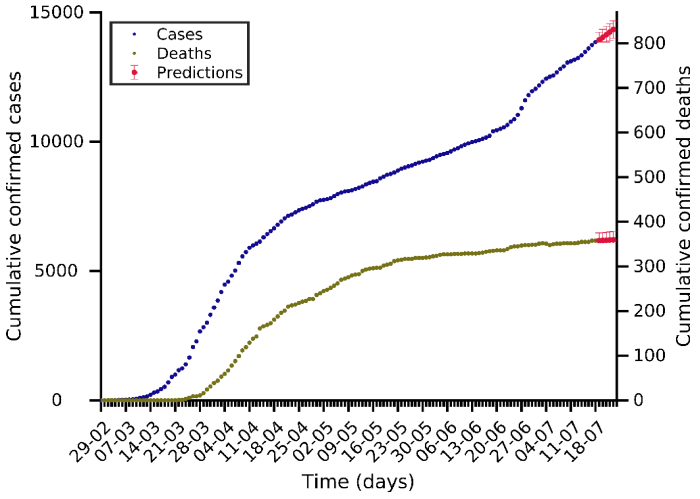


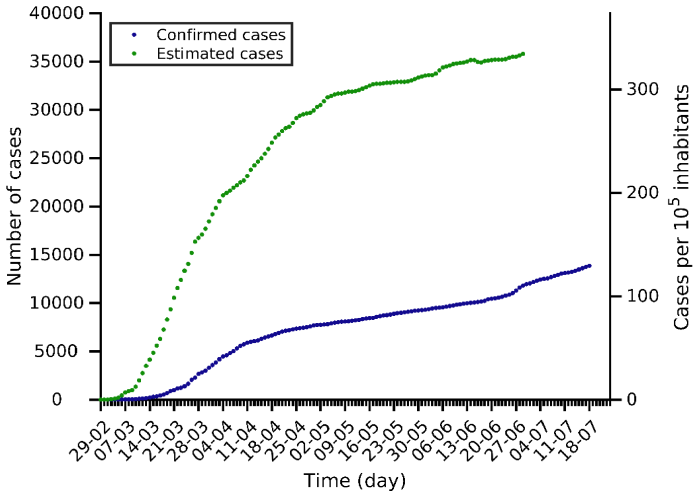


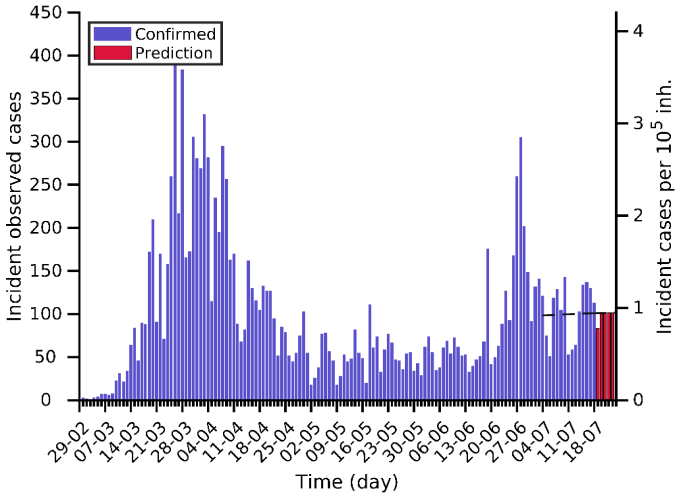


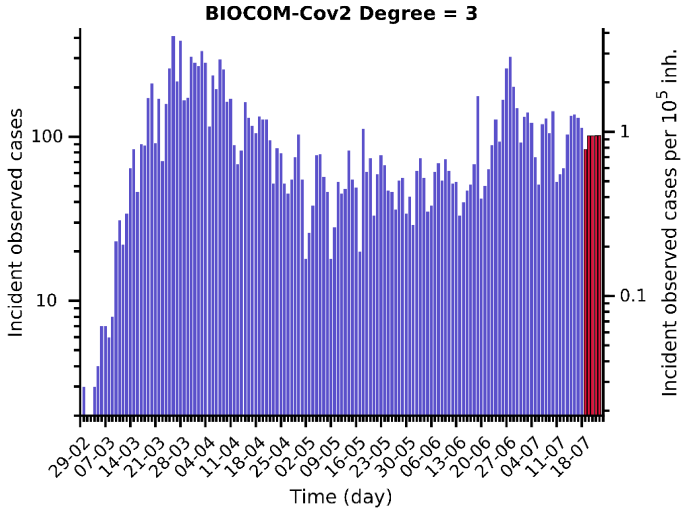


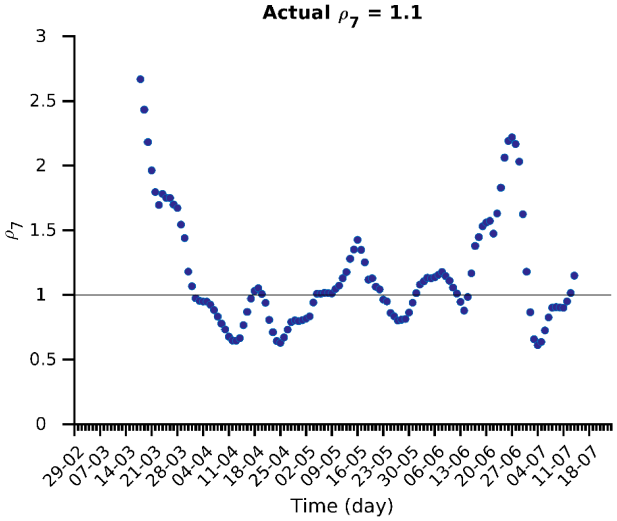
Czech Rep 18-07-2020. Pop: 10.7M. Cumulative incidence: 129/10⁵

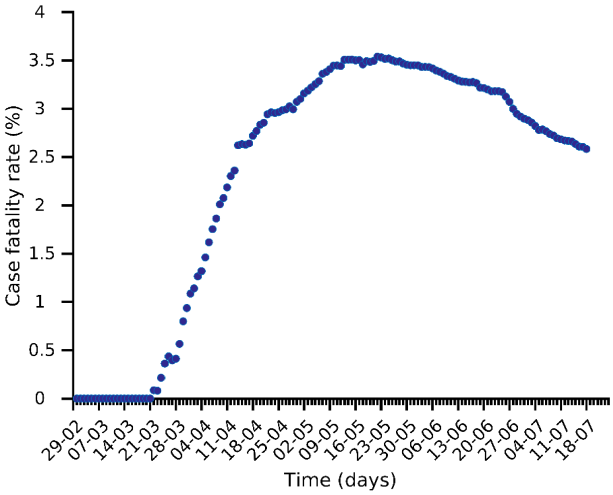


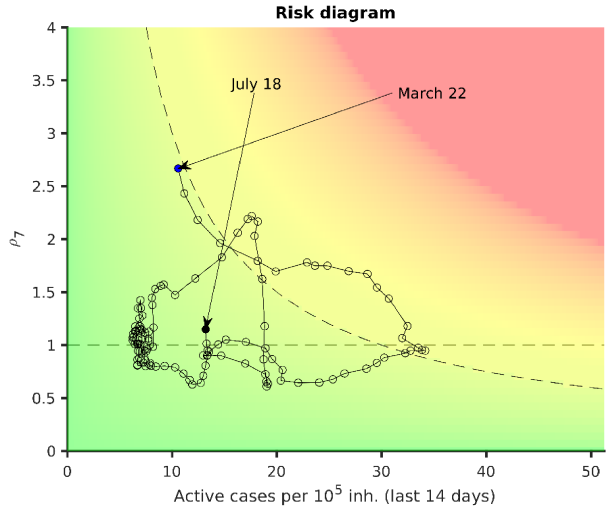


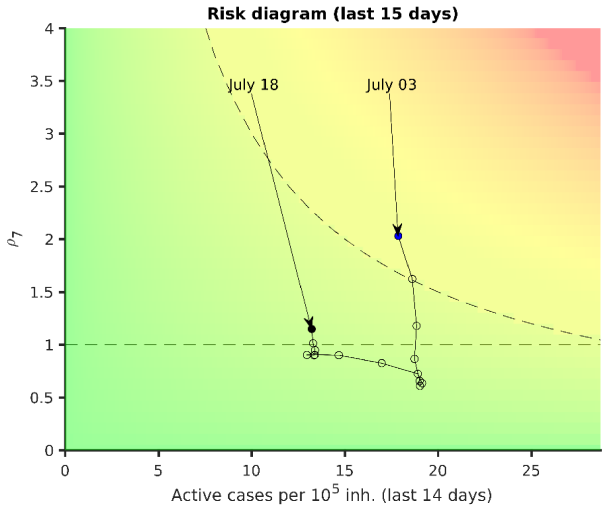




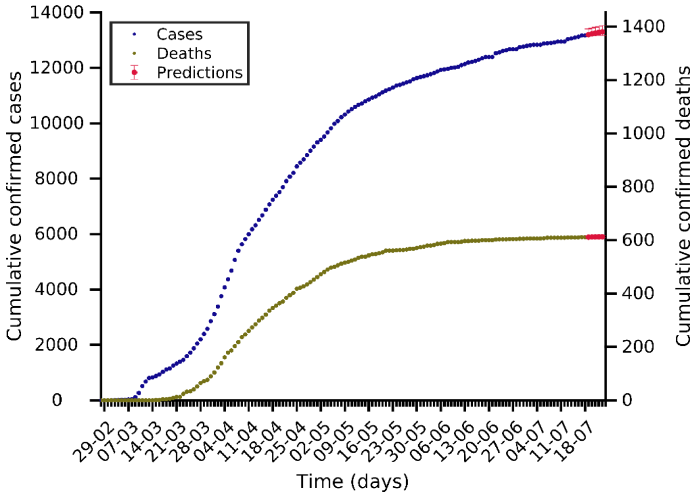


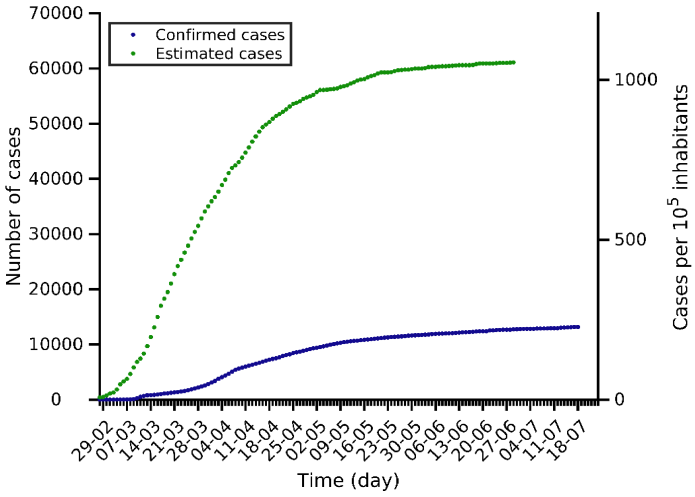


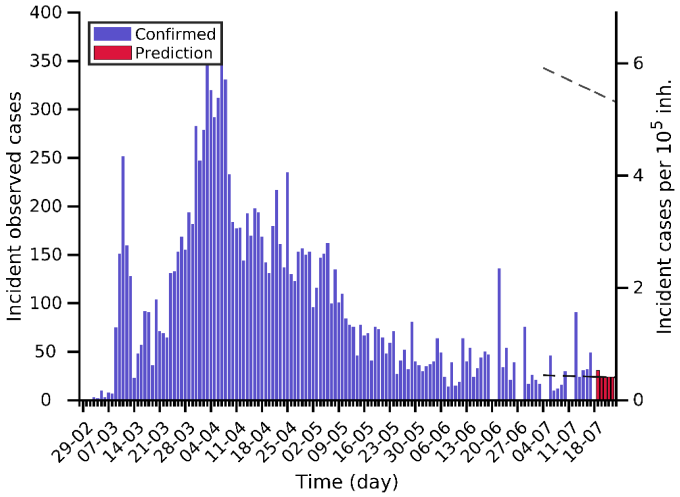


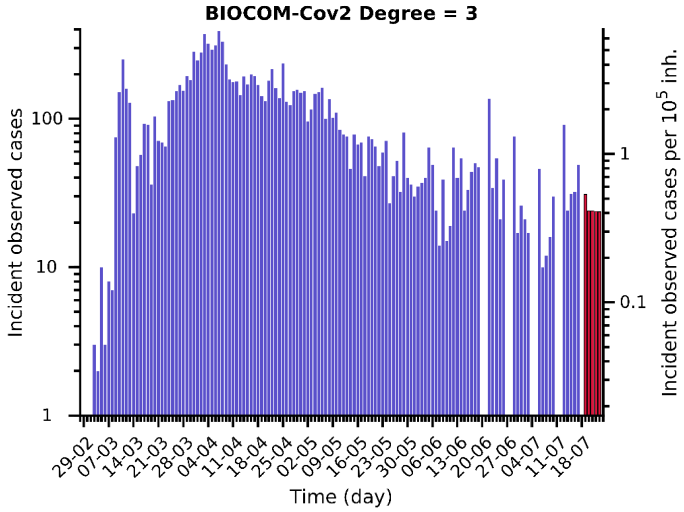


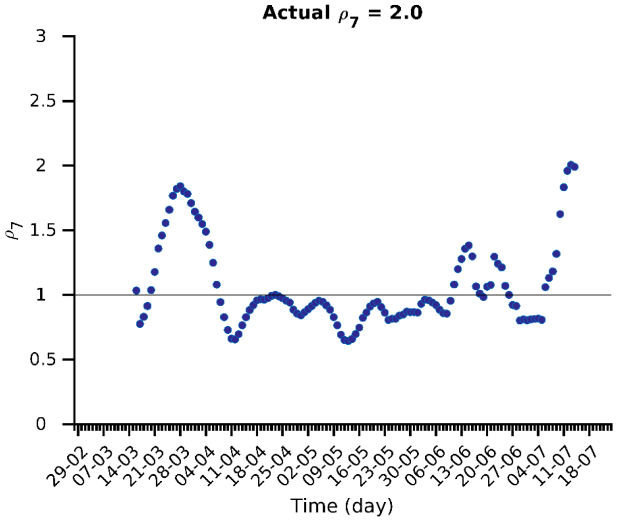
Denmark 18-07-2020. Pop: 5.8M. Cumulative incidence: 227/10⁵

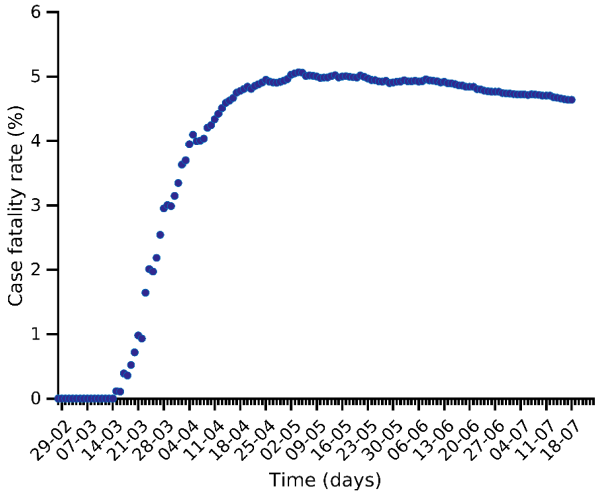


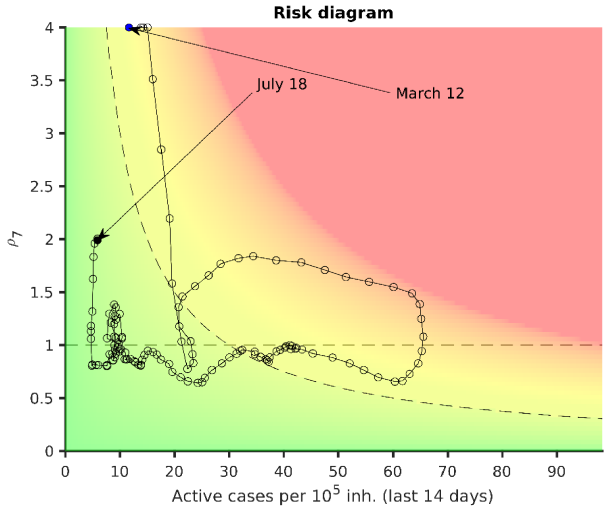


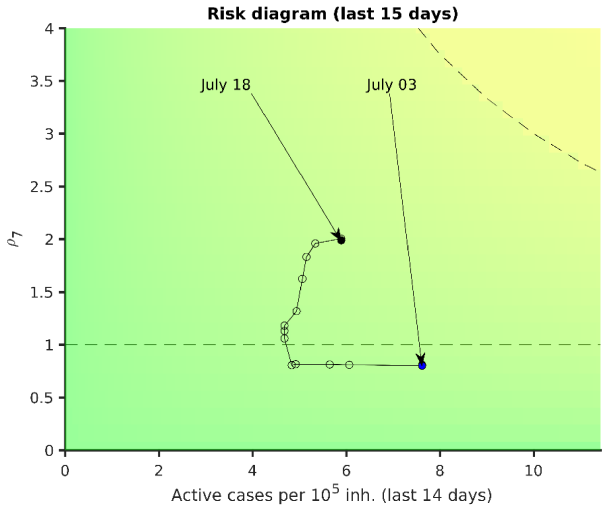




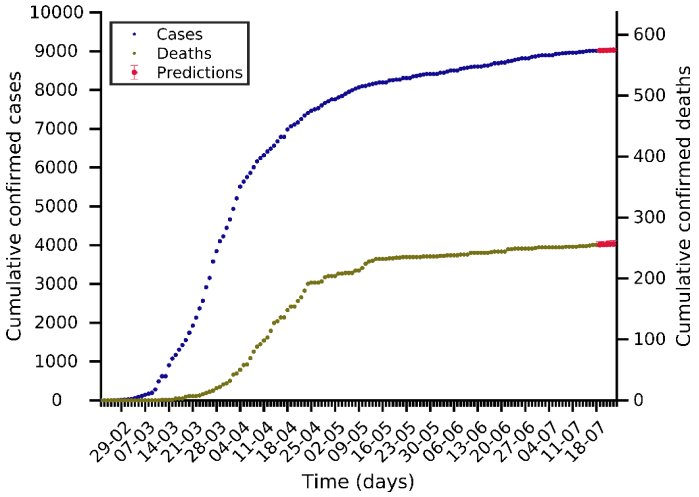


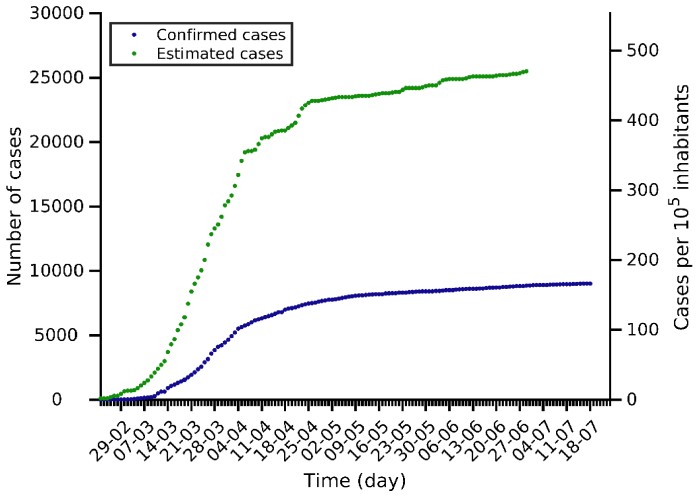


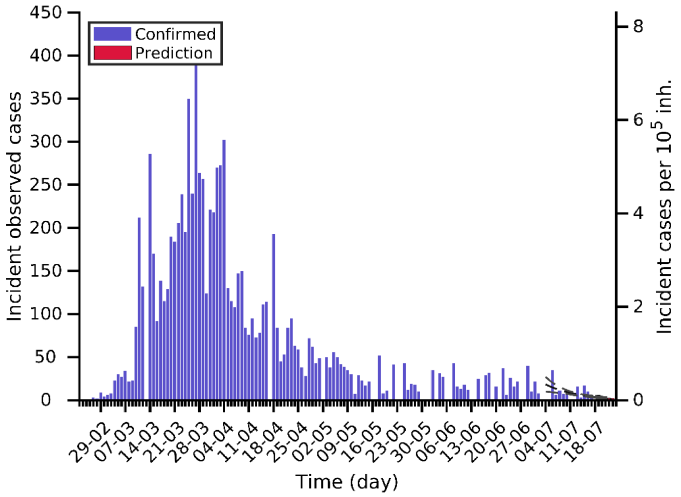


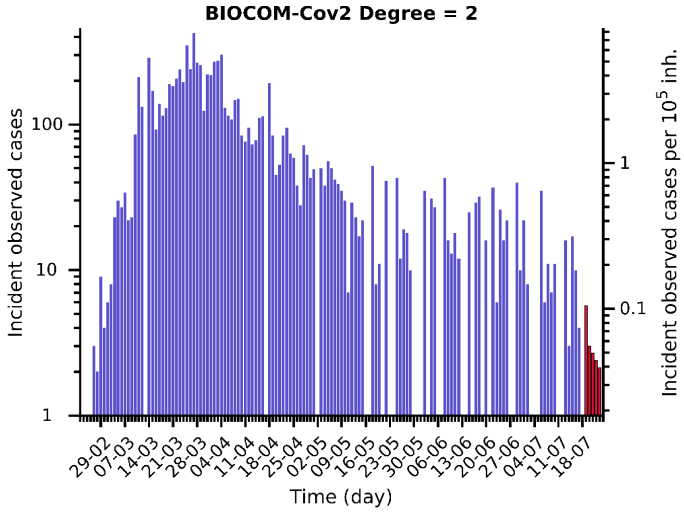


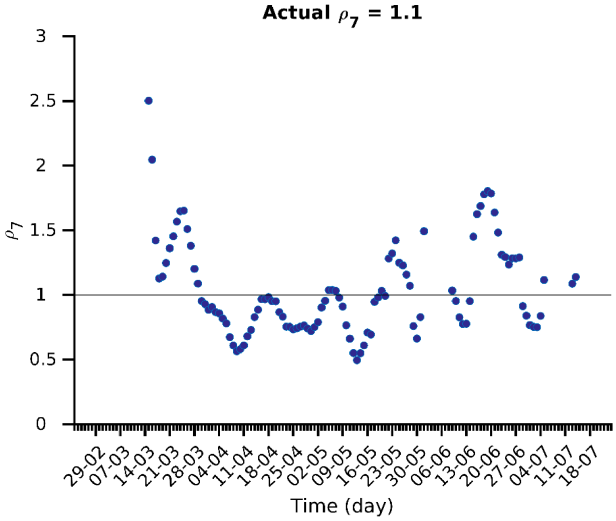
Norway 18-07-2020. Pop: 5.4M. Cumulative incidence: 166/10⁵

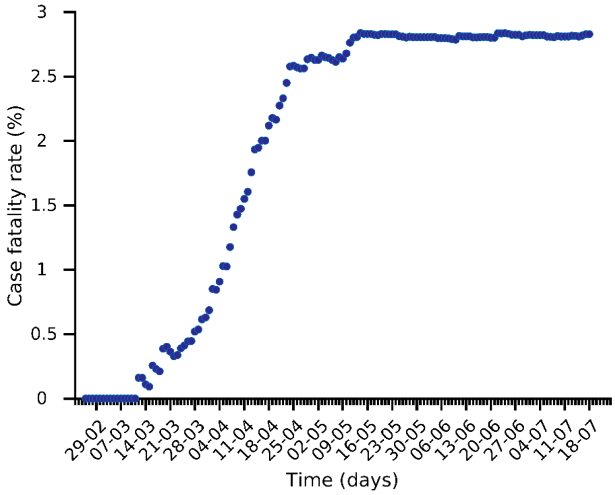


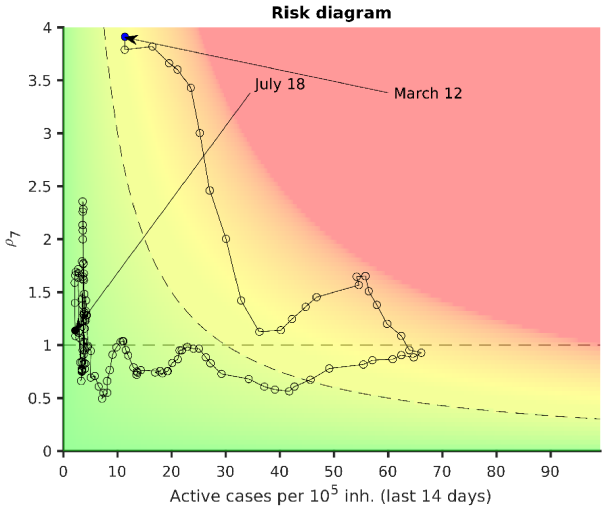


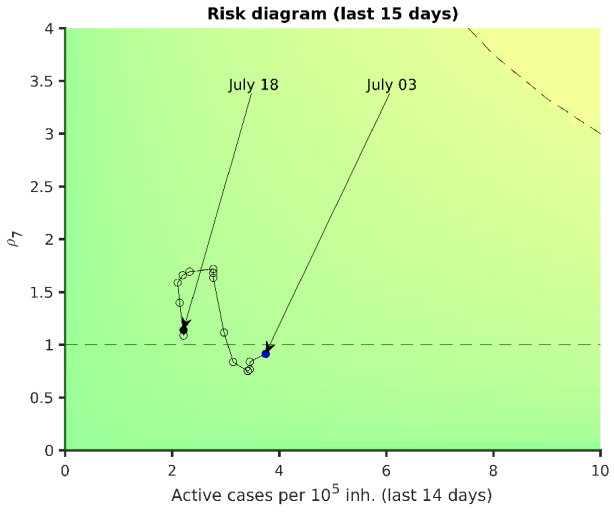




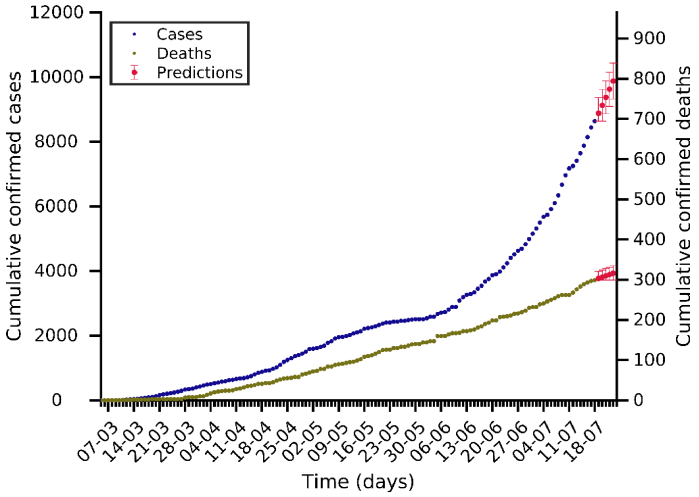


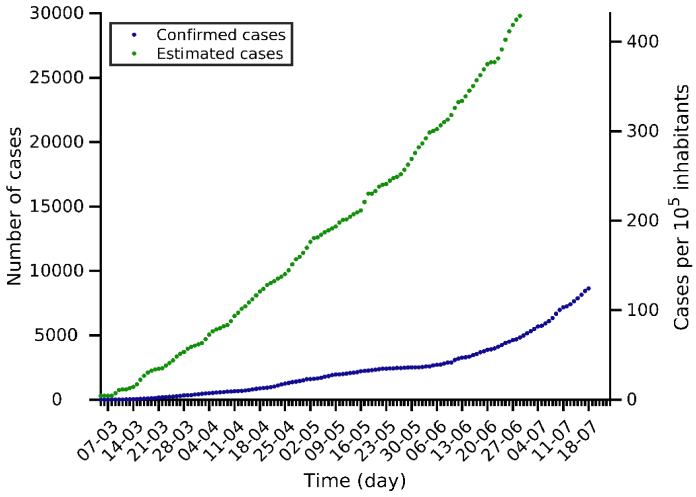


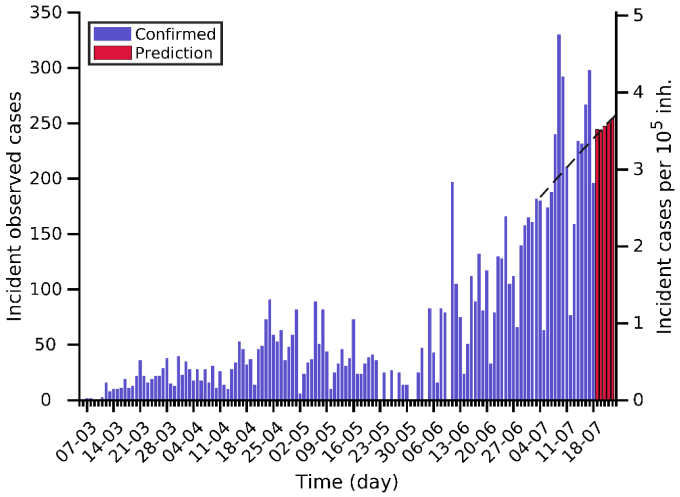


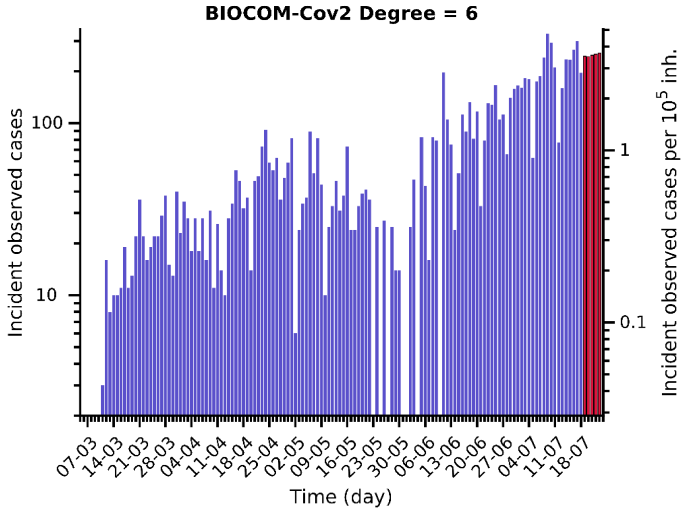


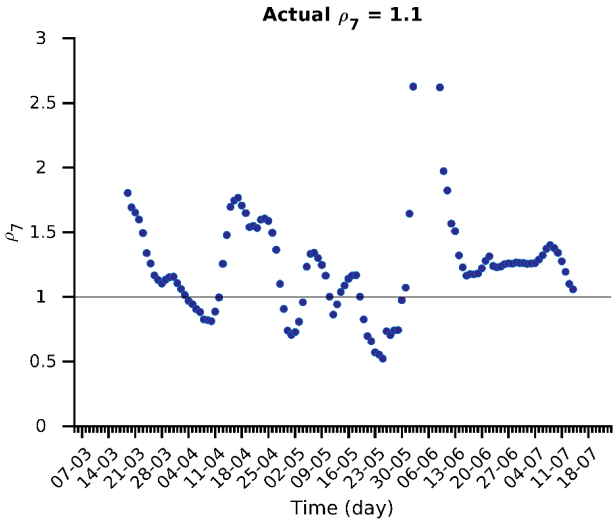
Bulgaria 18-07-2020. Pop: 6.9M. Cumulative incidence: 124/10⁵

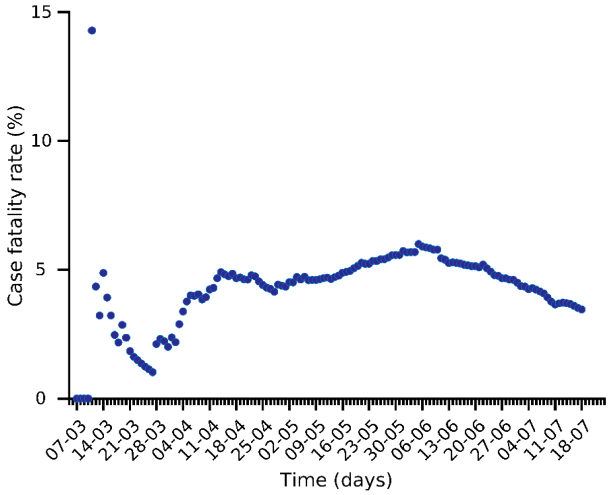


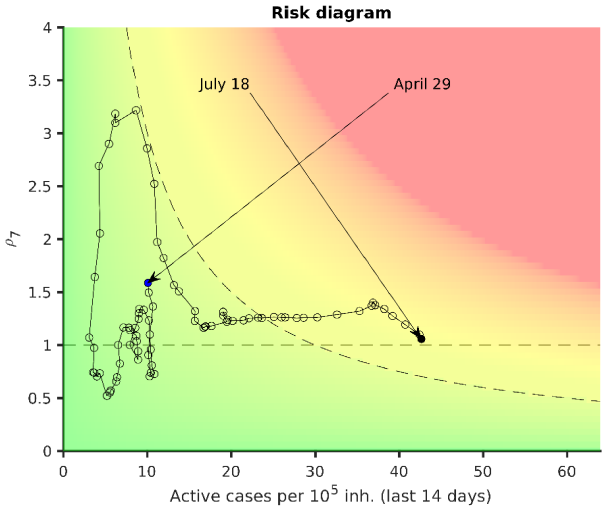


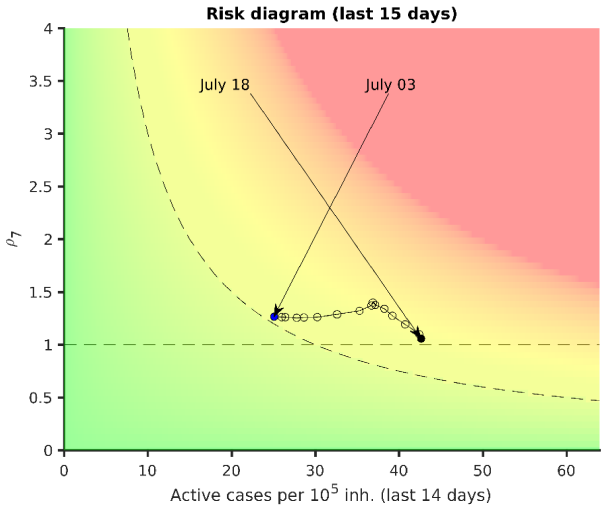




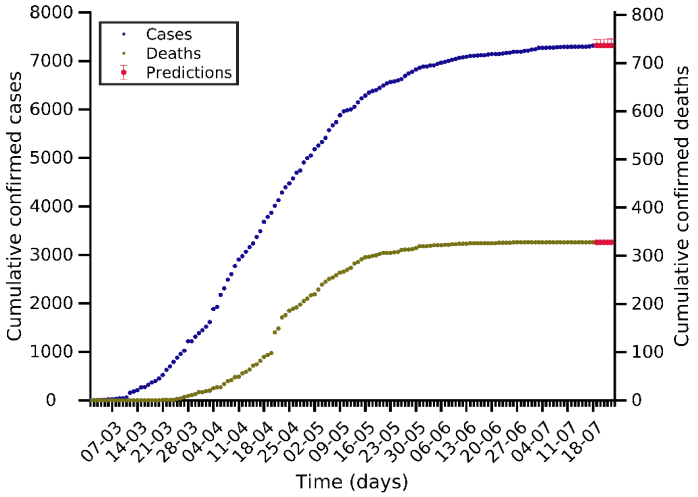


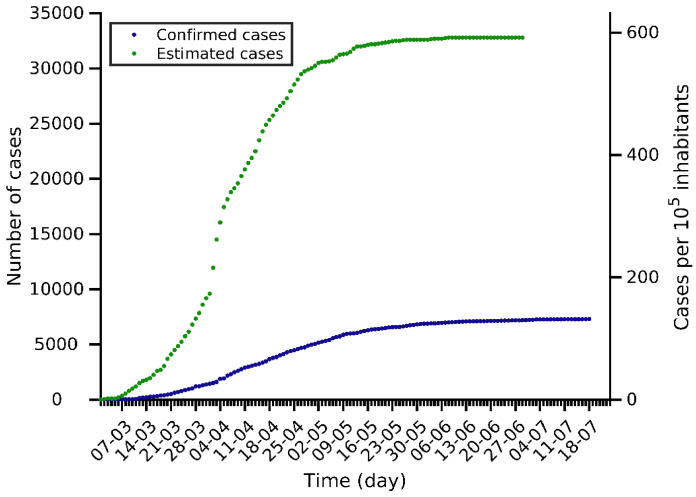


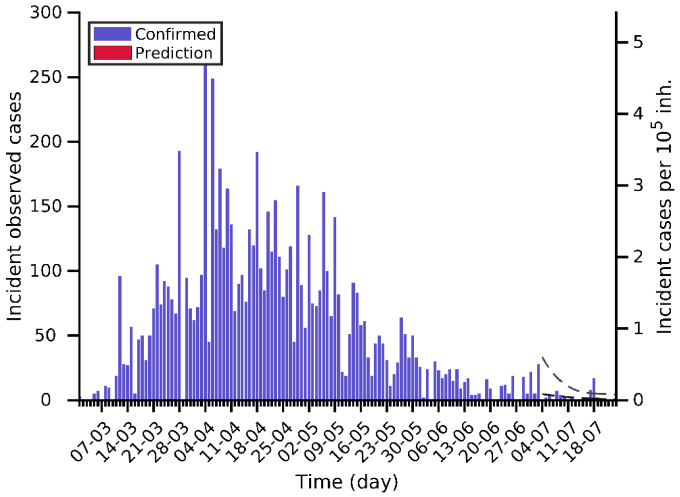


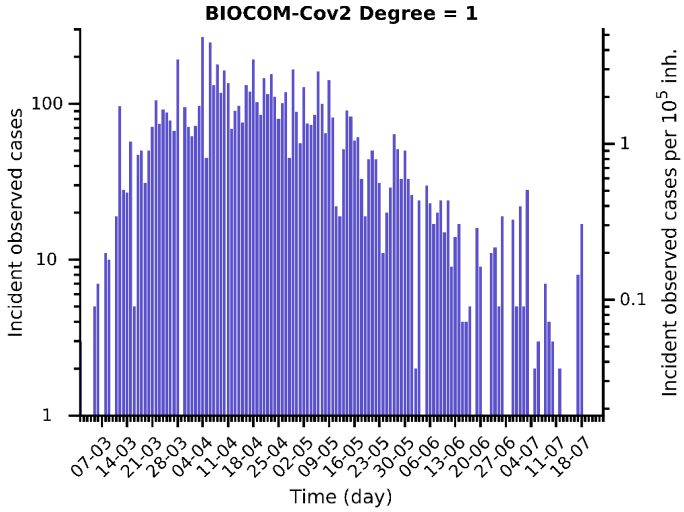


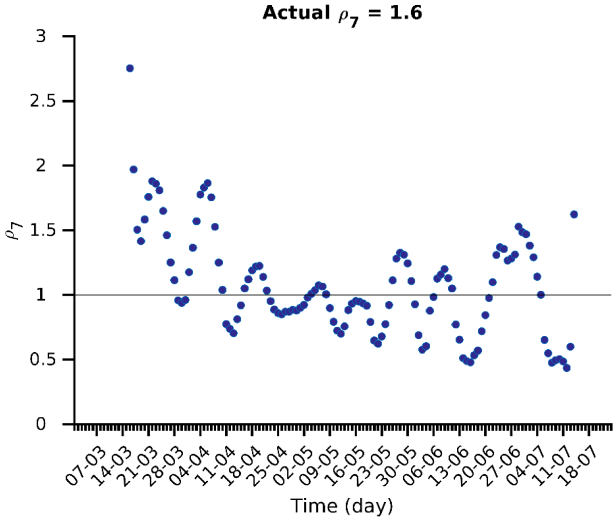
Finland 18-07-2020. Pop: 5.5M. Cumulative incidence: 132/10^5

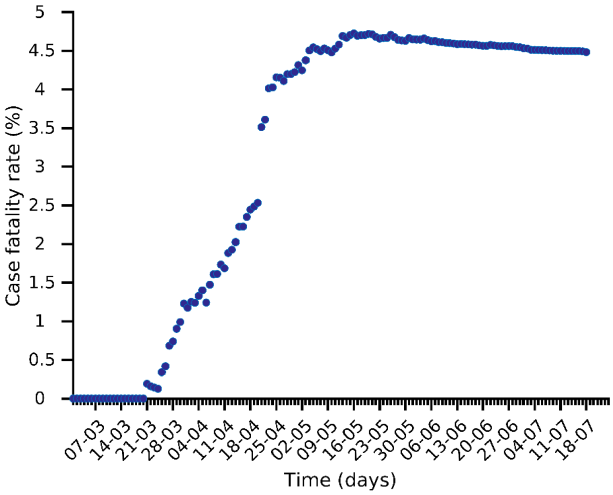


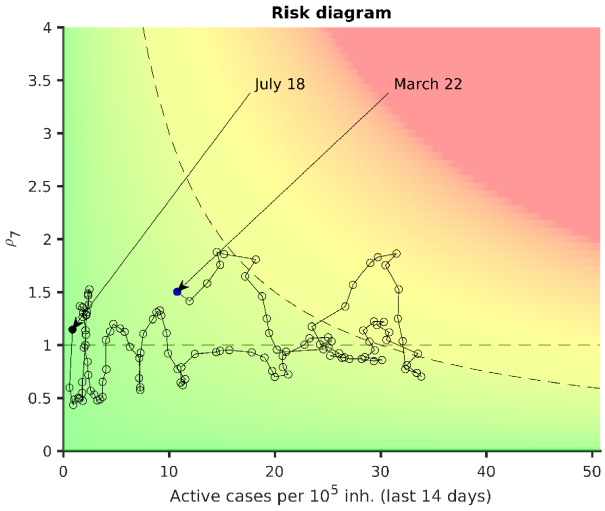


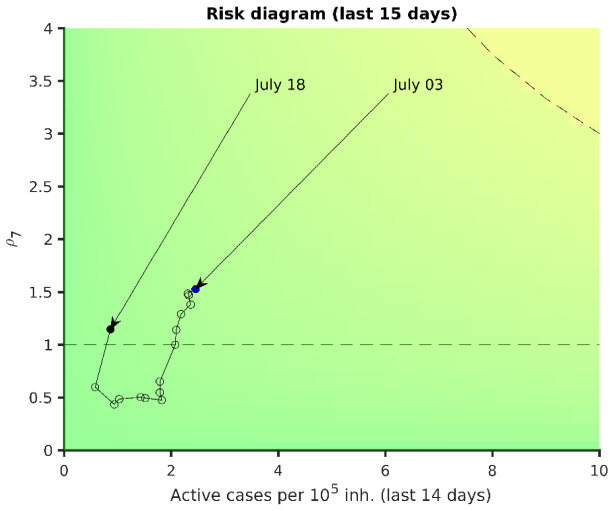




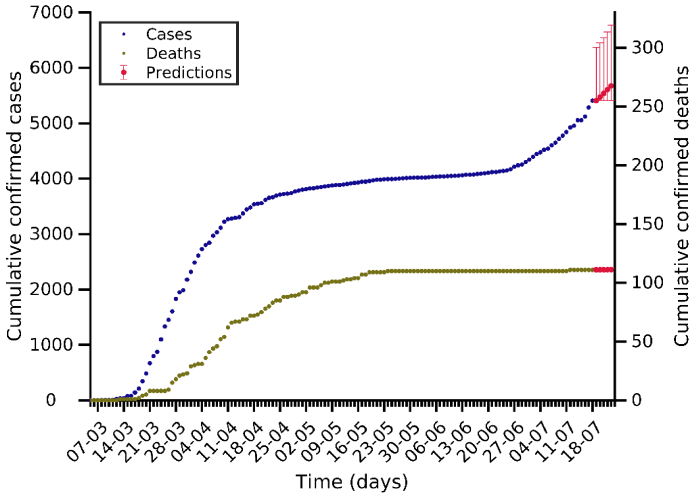


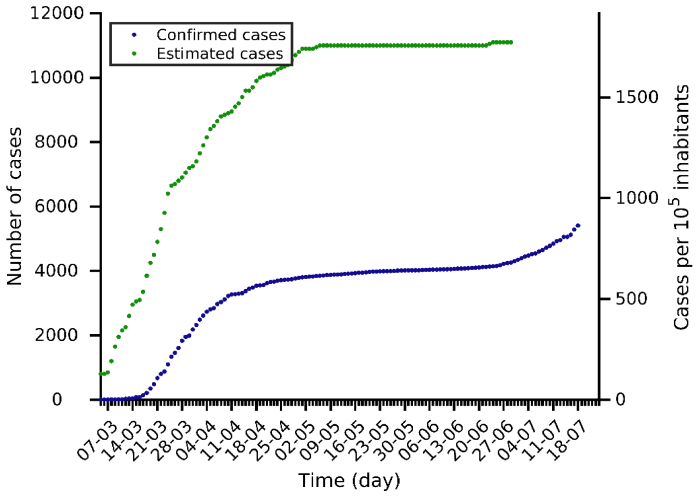


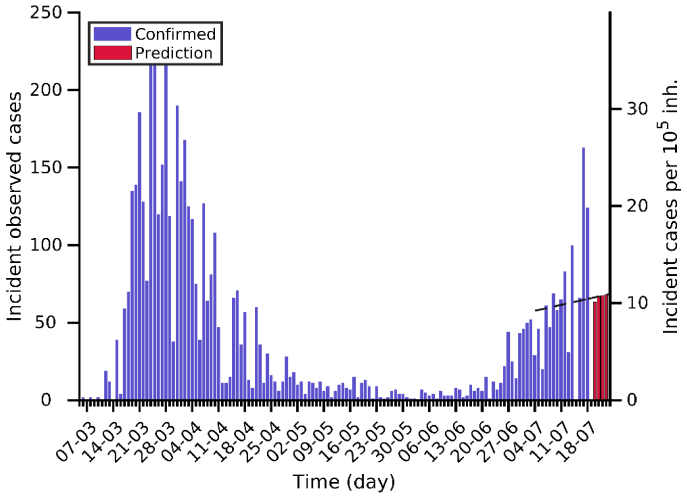


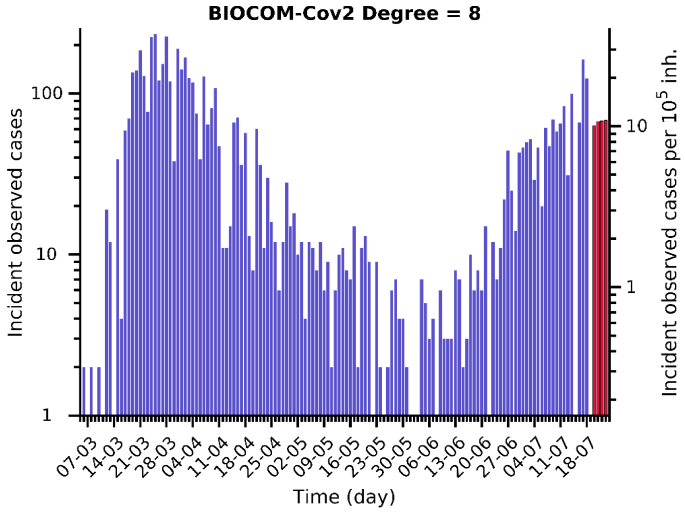


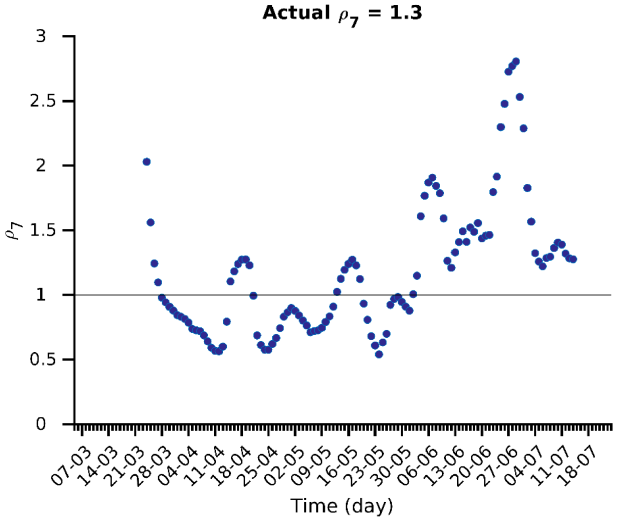
Luxembourg 18-07-2020. Pop: 0.6M. Cumulative incidence: 864/10⁵

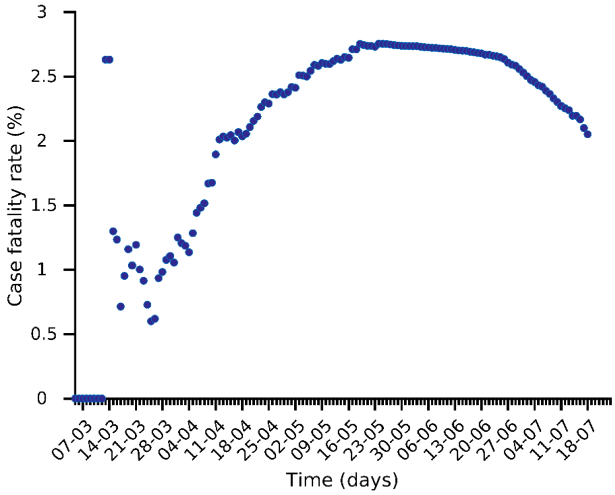


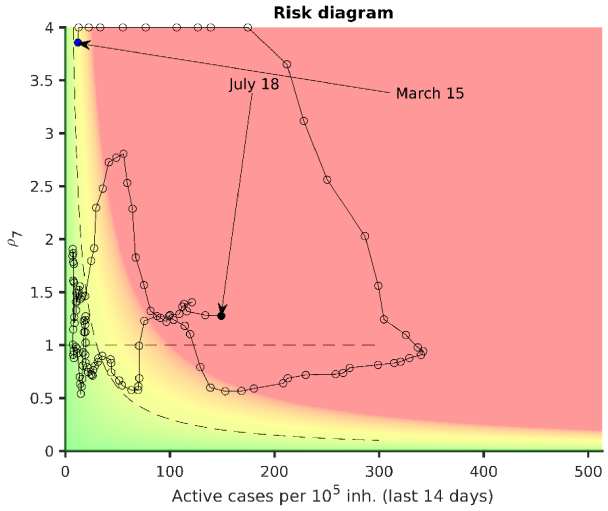


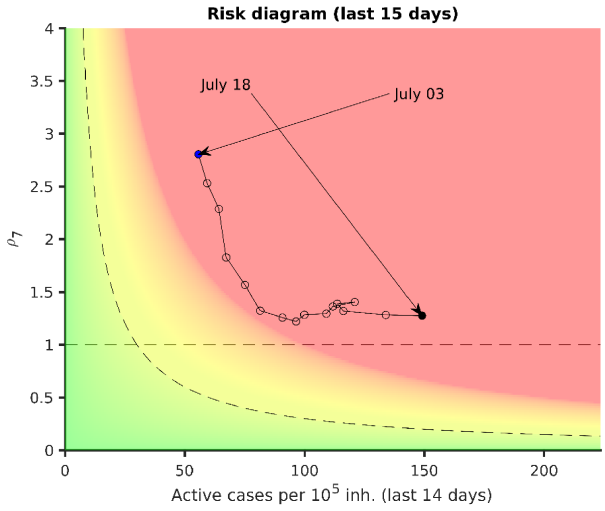




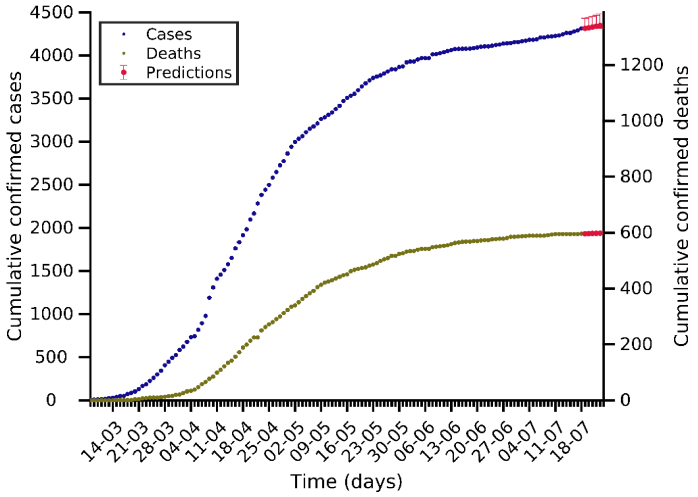


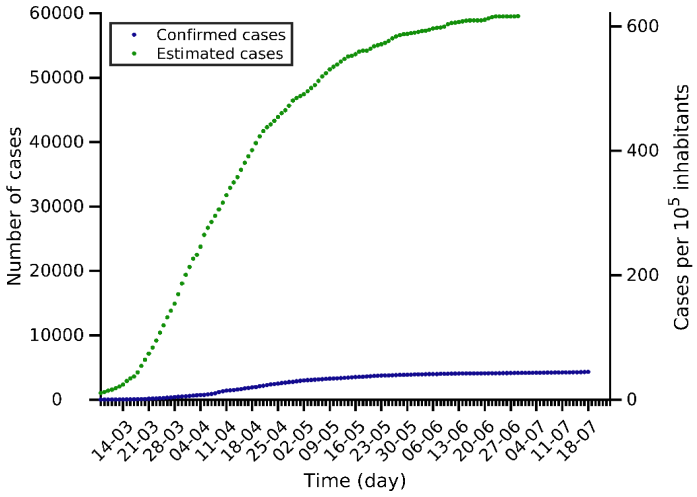


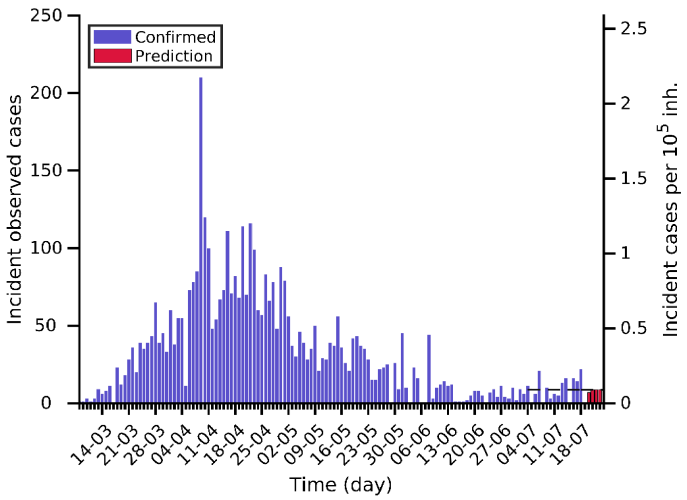


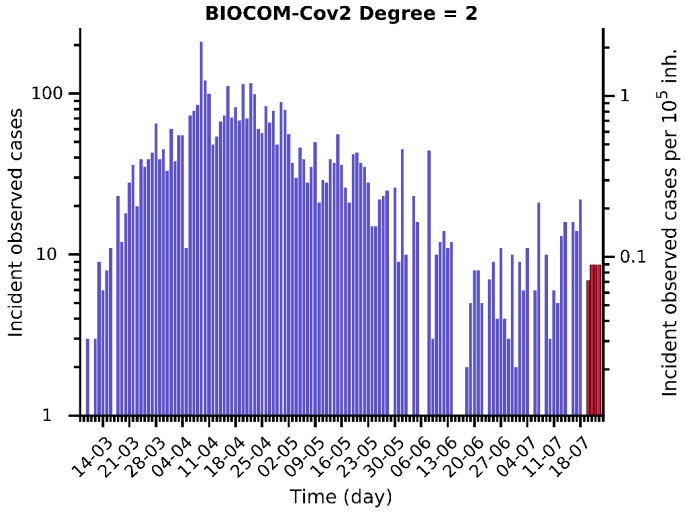


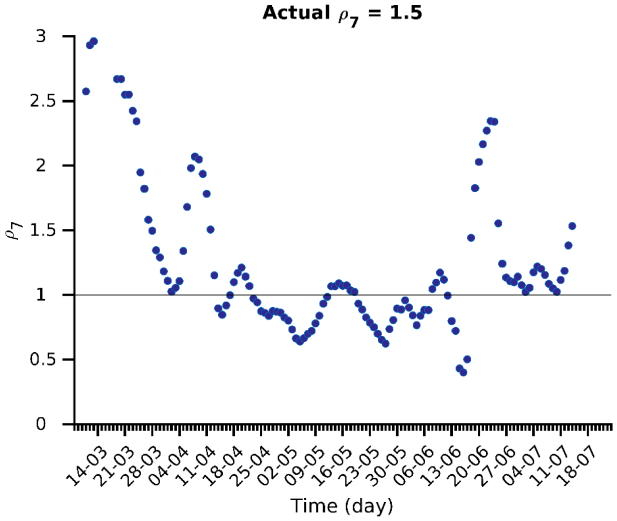
Hungary 18-07-2020. Pop: 9.7M. Cumulative incidence: 45/10⁵

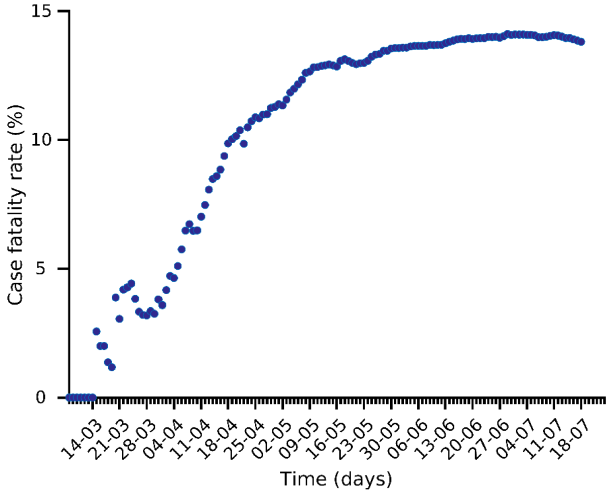


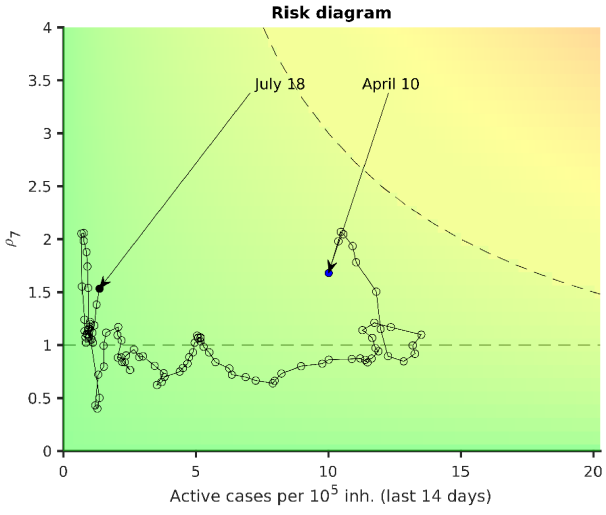


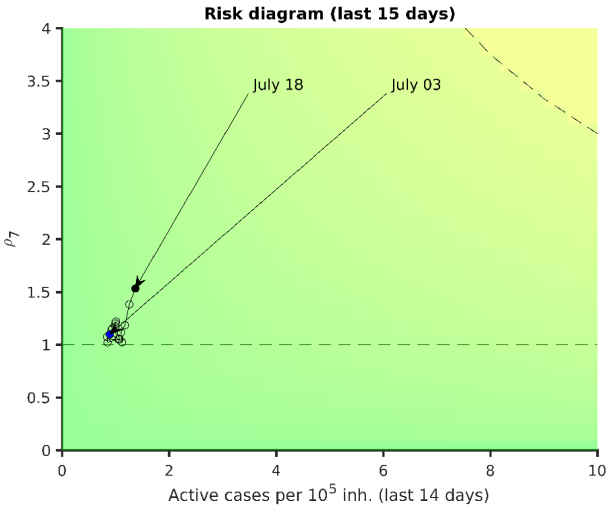




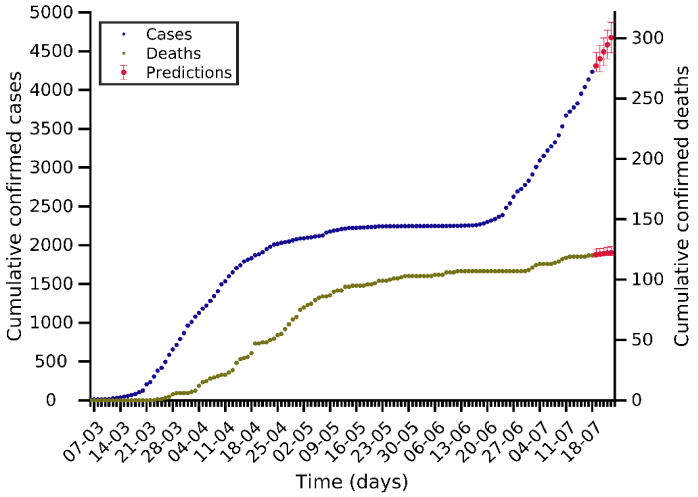


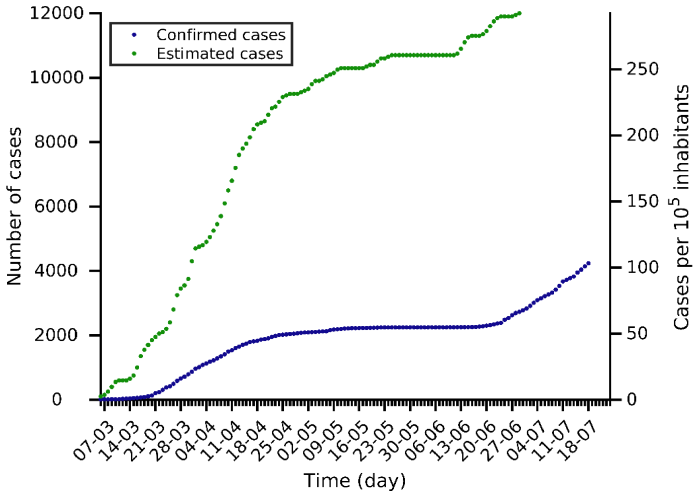


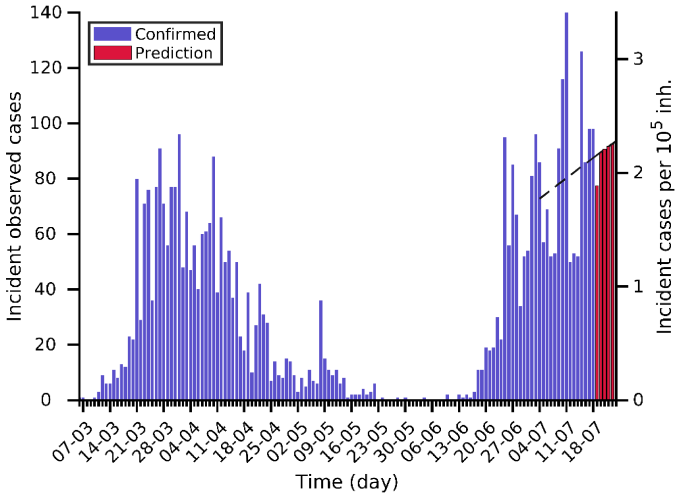


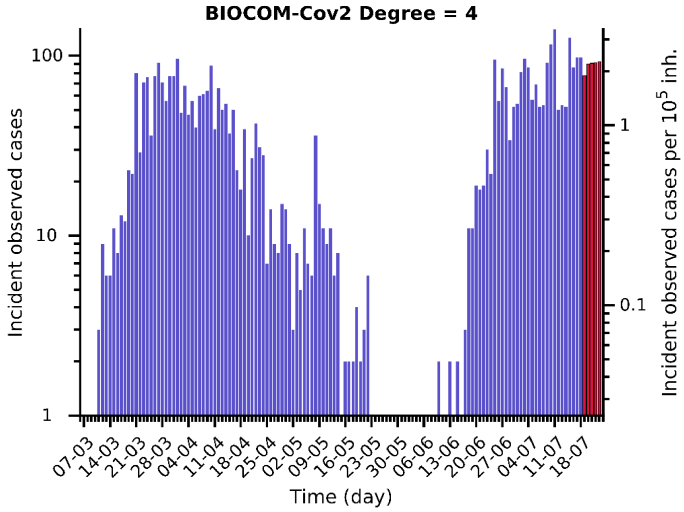


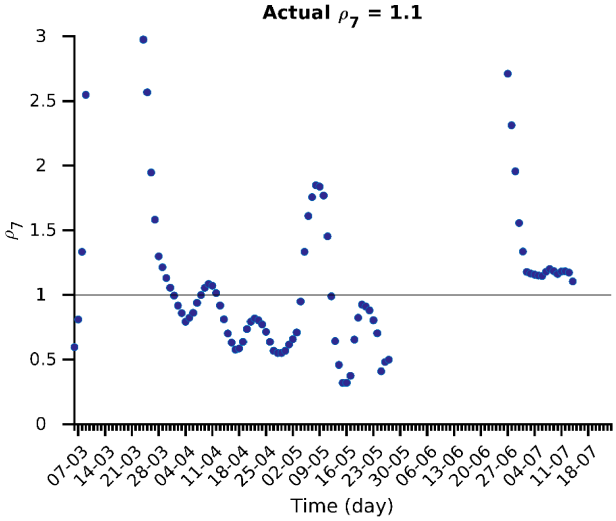
Croatia 18-07-2020. Pop: 4.1M. Cumulative incidence: 103/10⁵

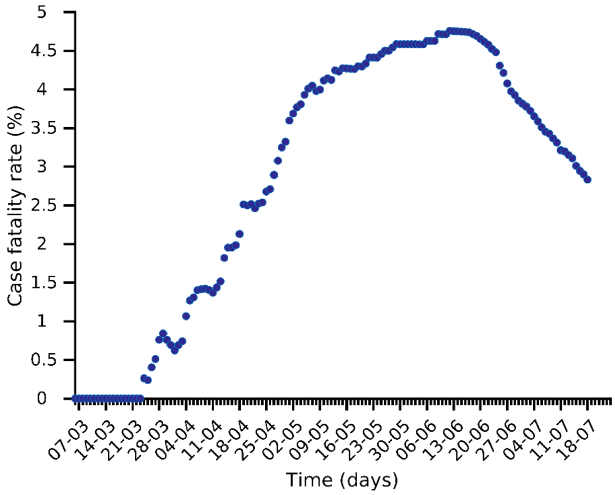


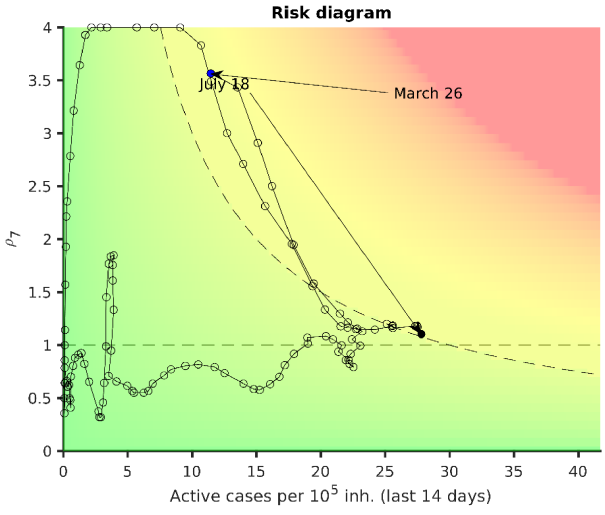


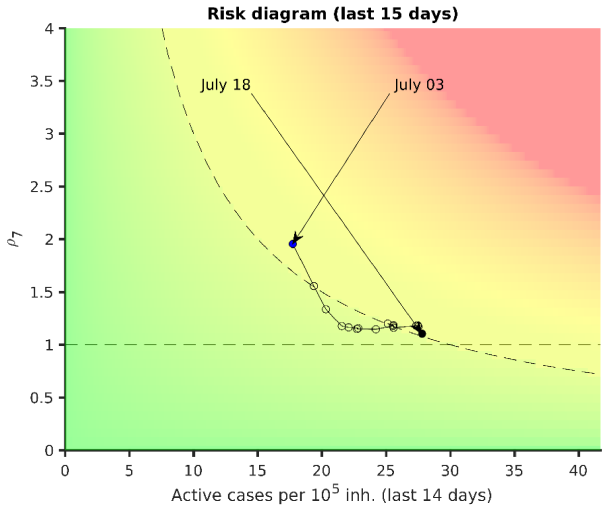




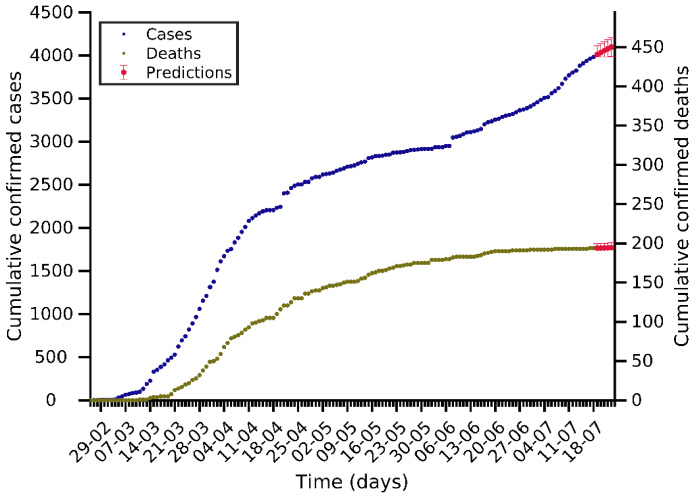


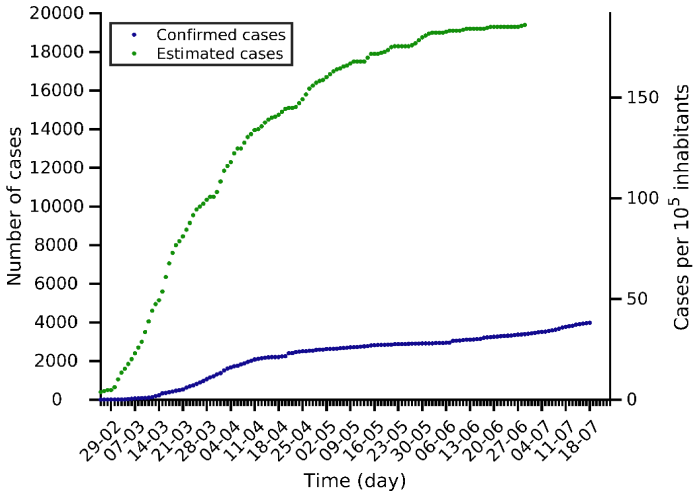


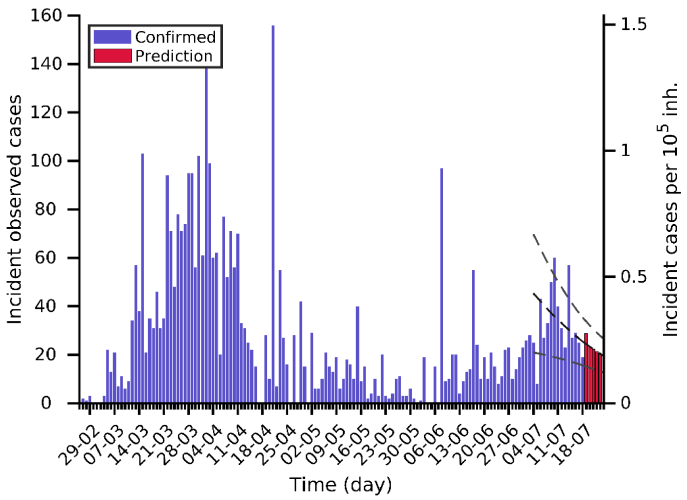


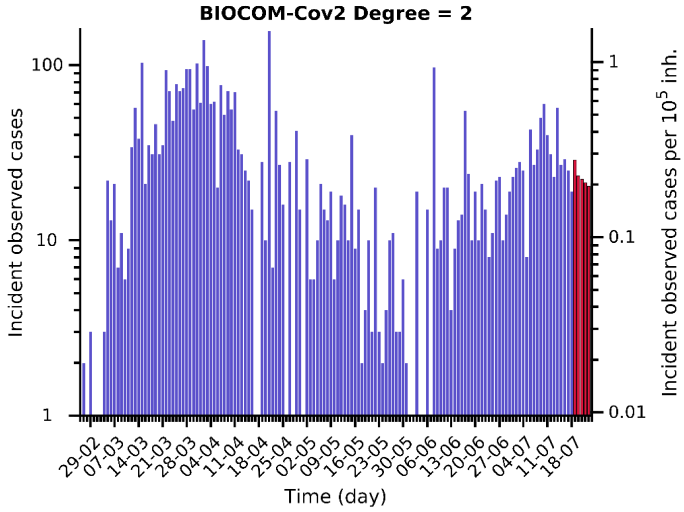


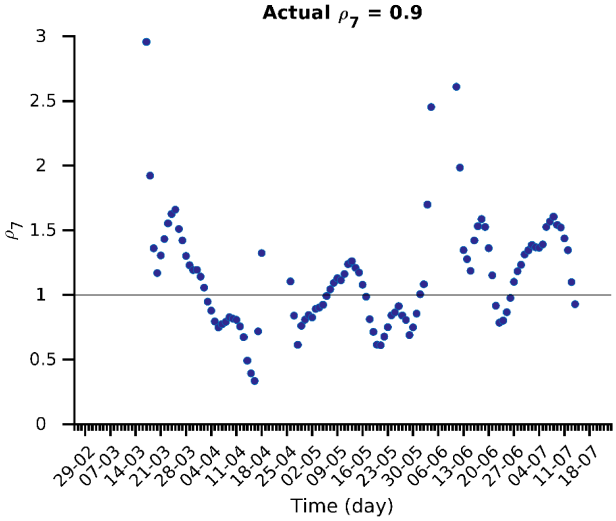
Greece 18-07-2020. Pop: 10.4M. Cumulative incidence: 38/10^5

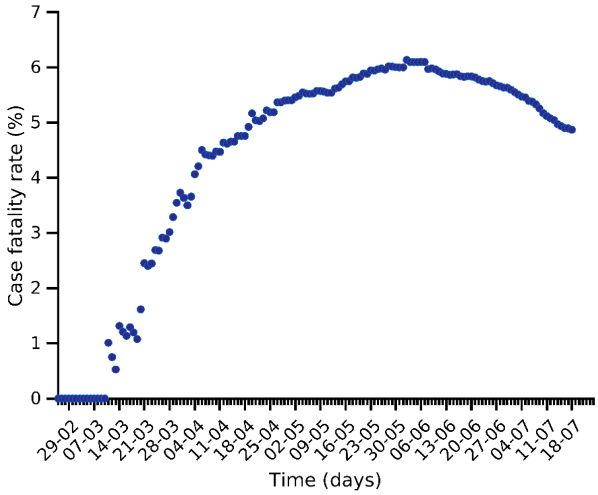


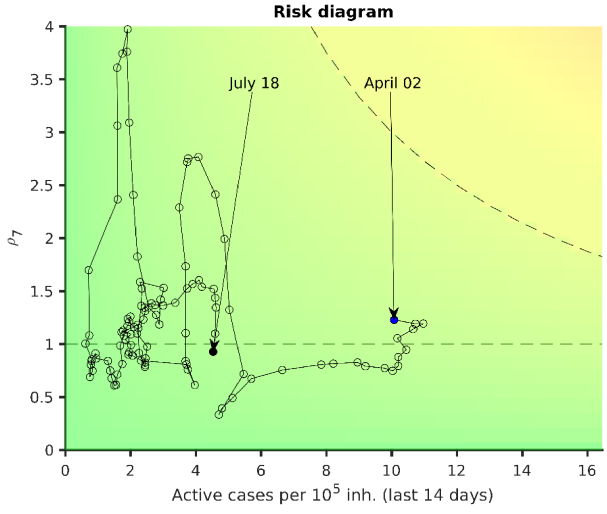


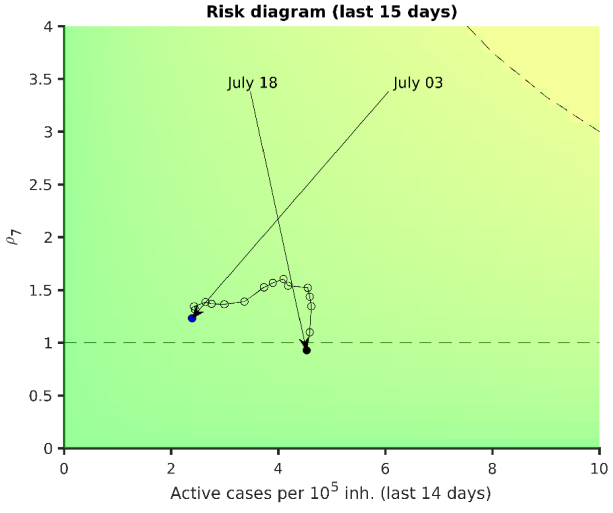




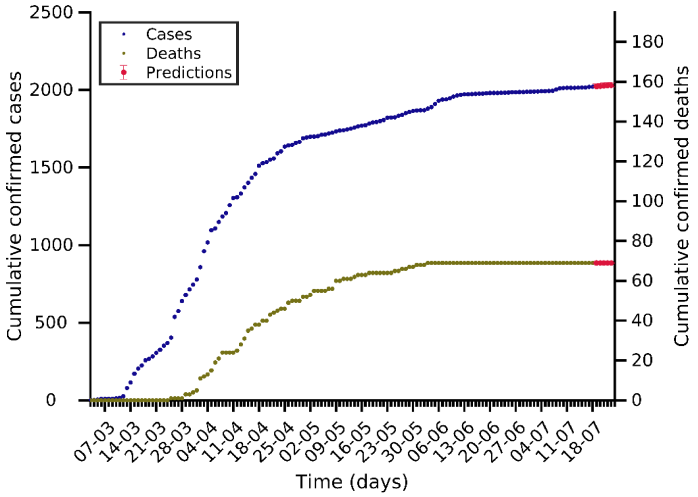


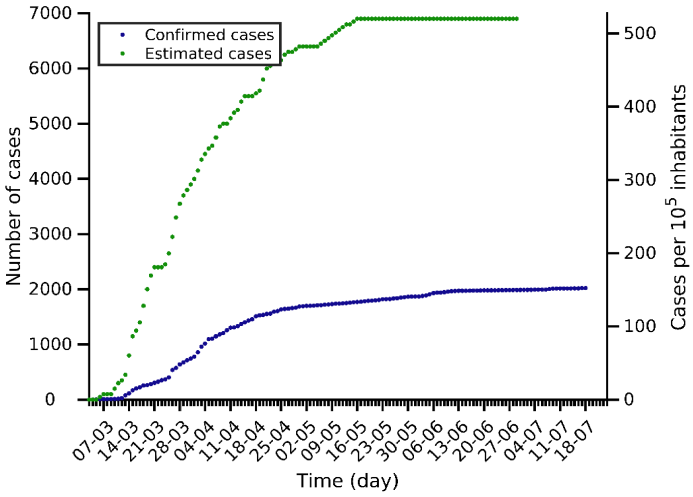


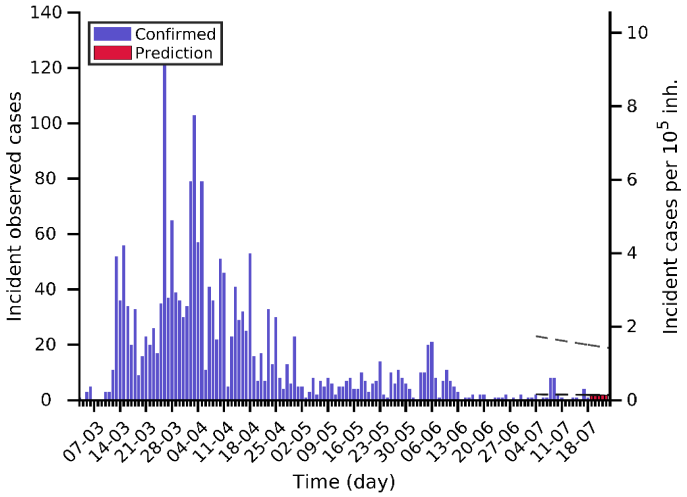


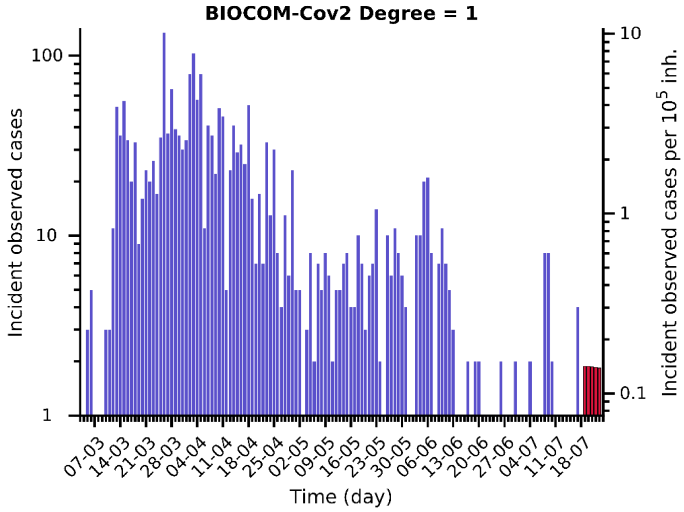


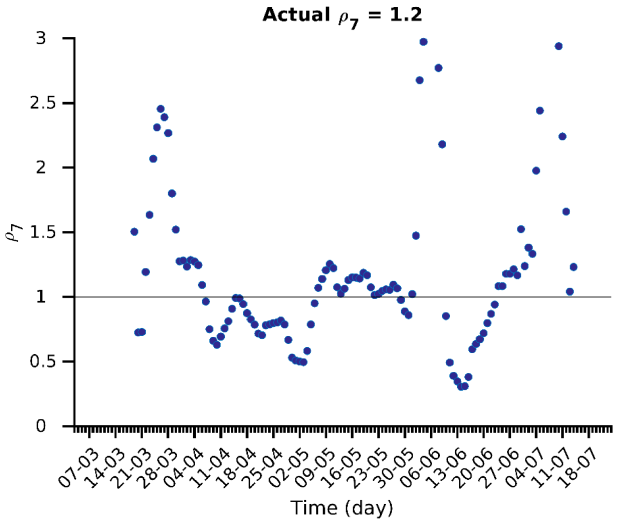
Estonia 18-07-2020. Pop: 1.3M. Cumulative incidence: 152/10⁵

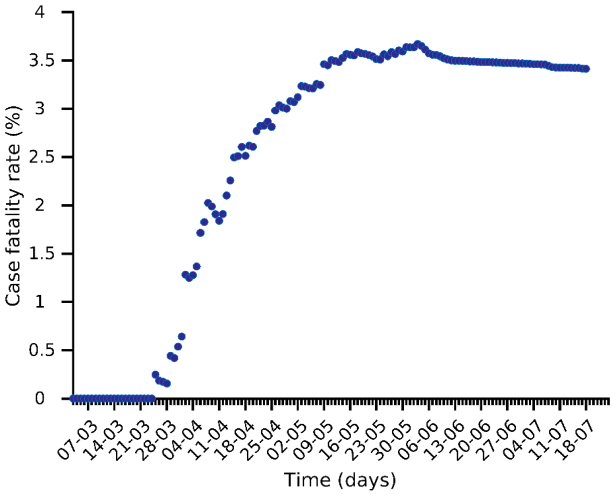


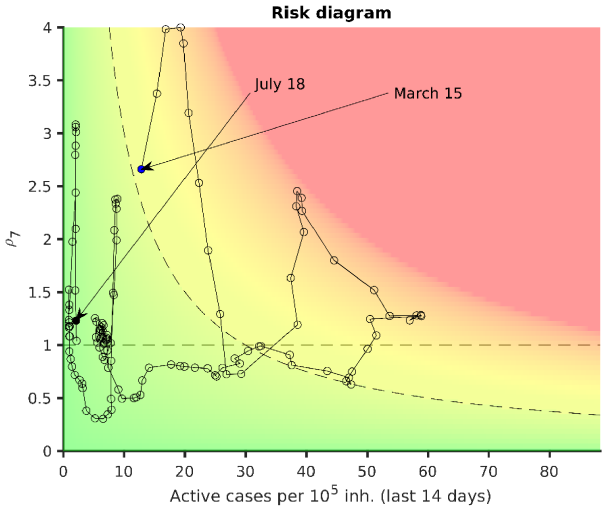


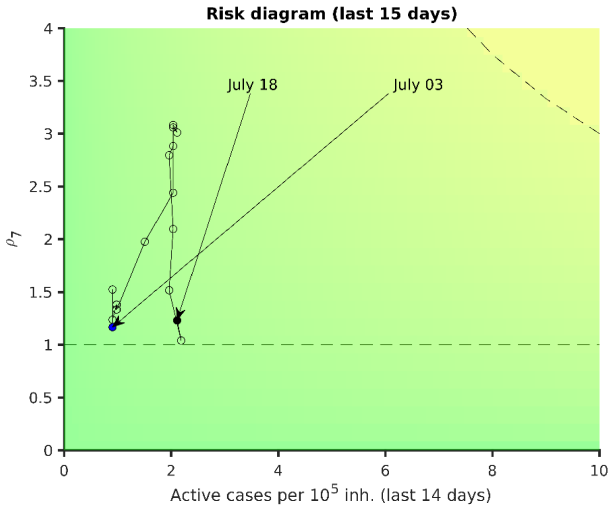




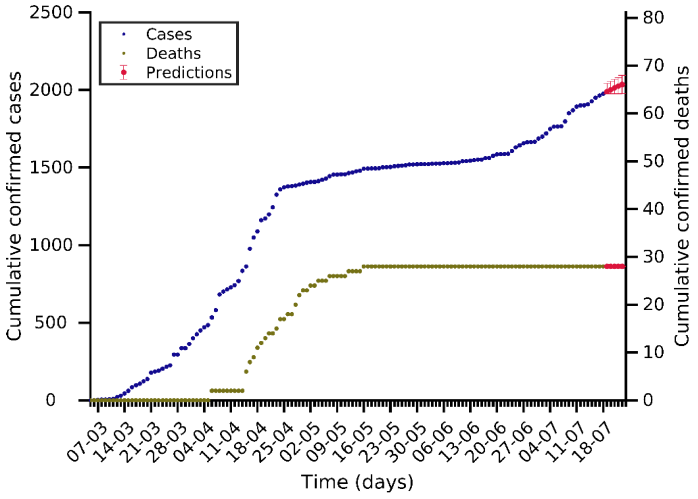


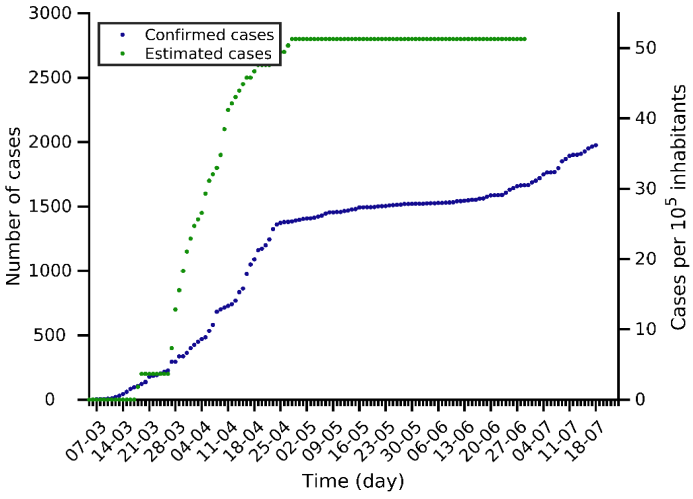


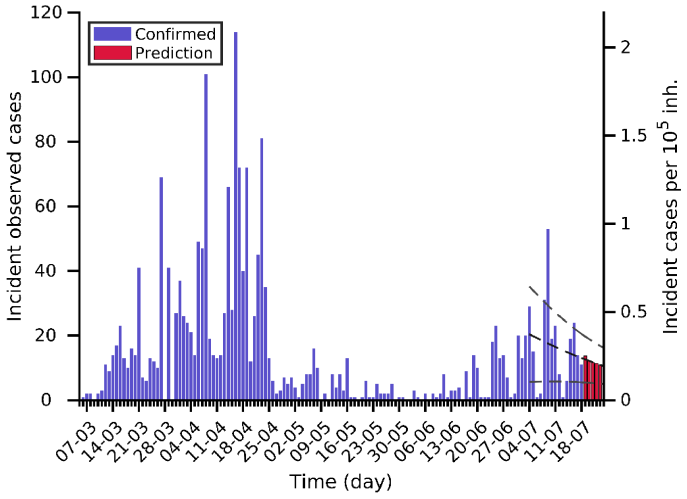


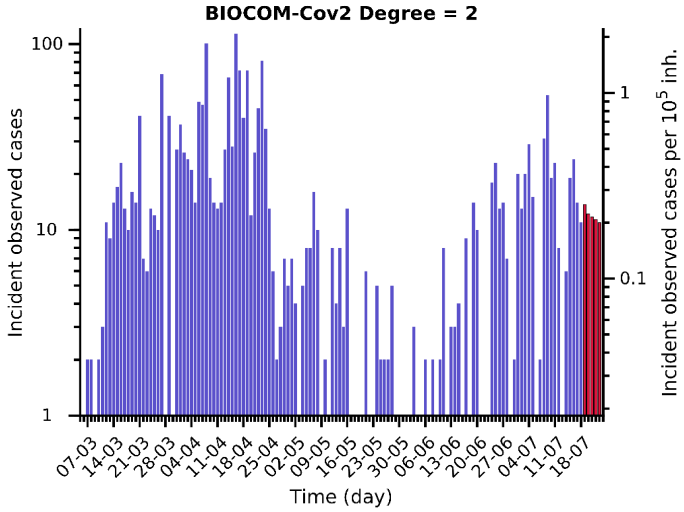


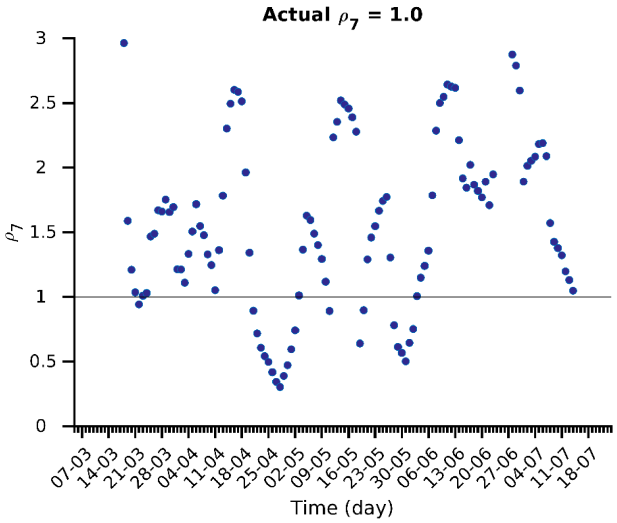
Slovakia 18-07-2020. Pop: 5.5M. Cumulative incidence: 36/10^5

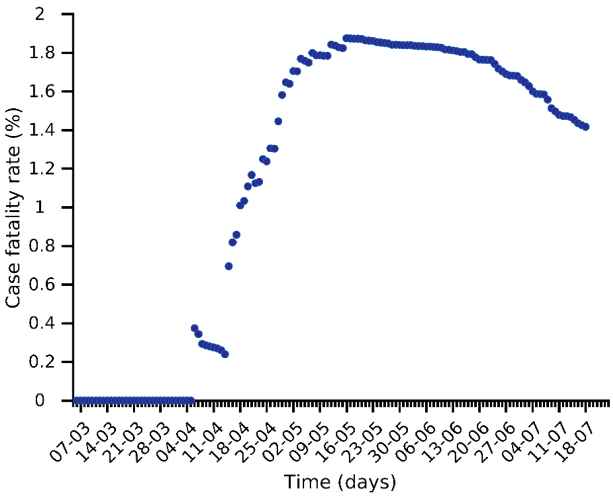


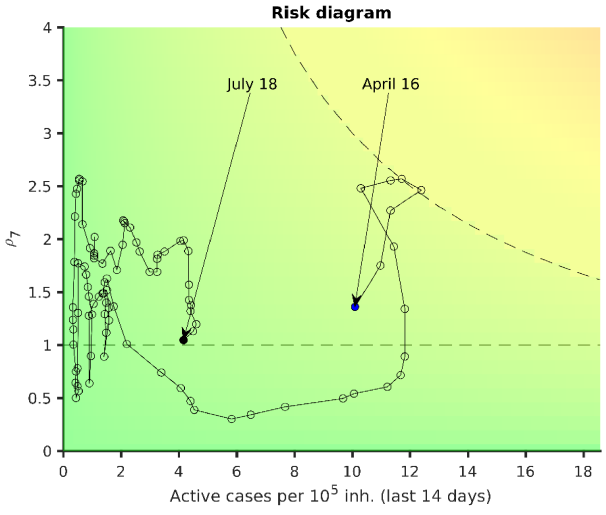


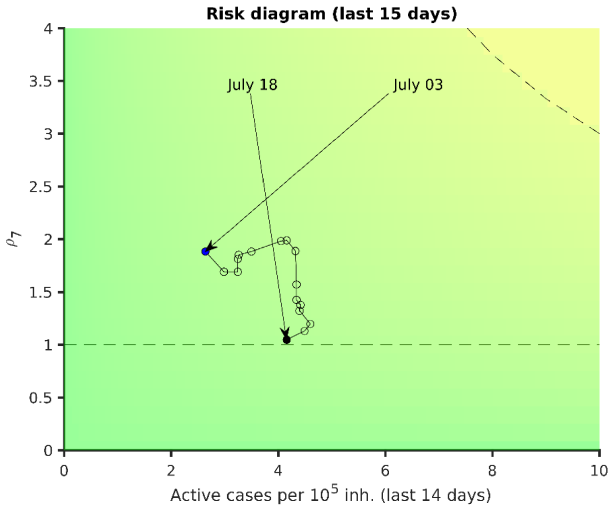




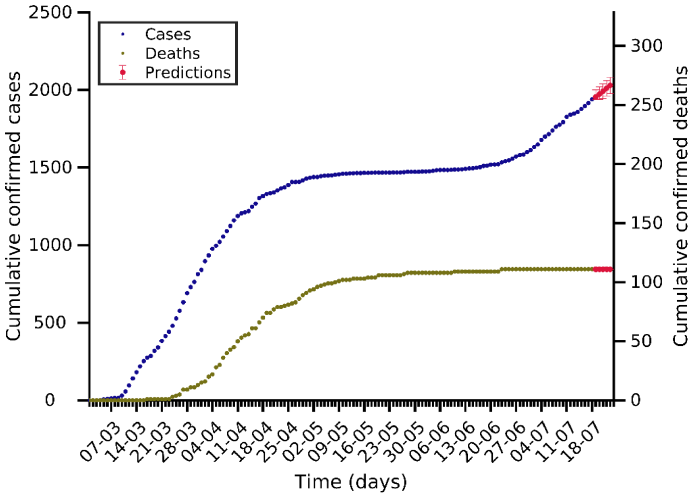


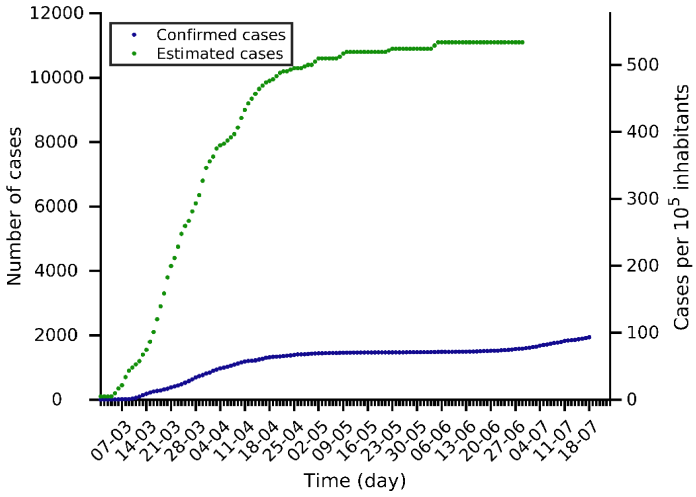


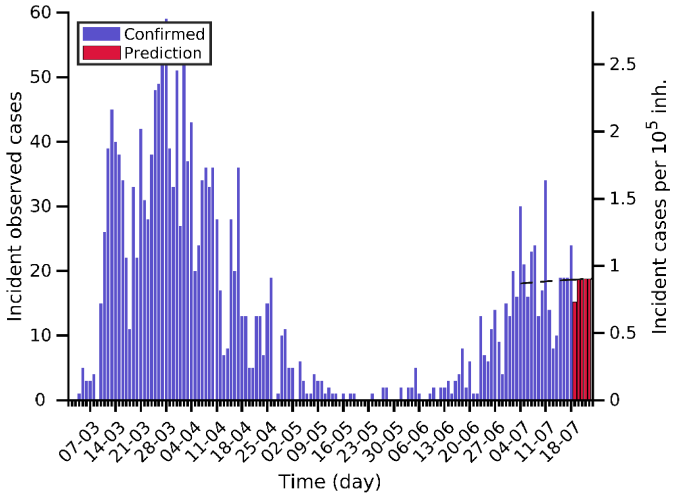


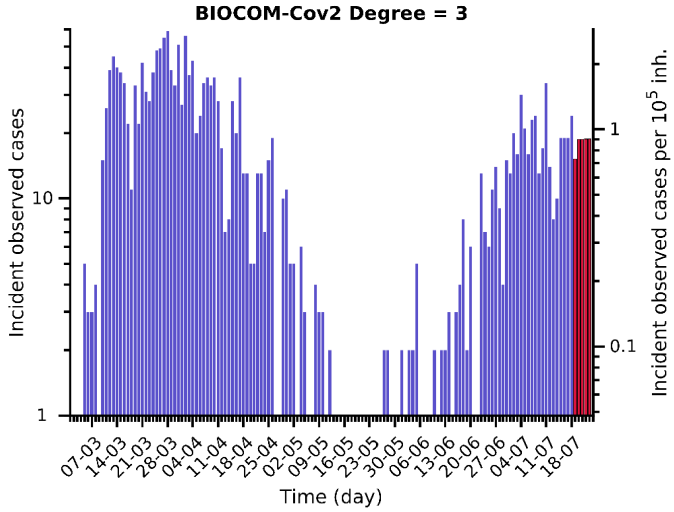


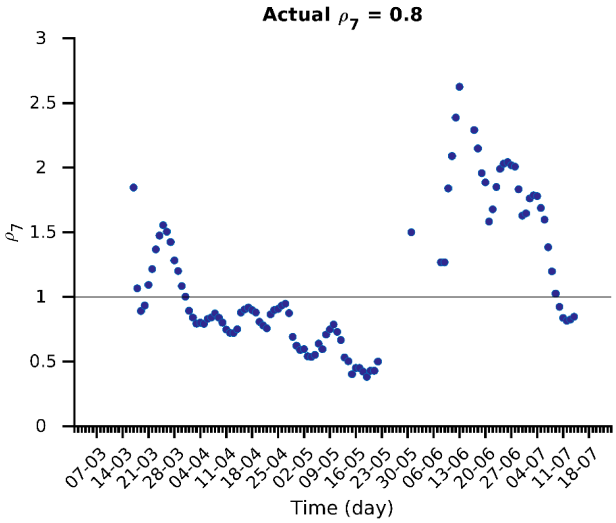
Slovenia 18-07-2020. Pop: 2.1M. Cumulative incidence: 93/10⁵

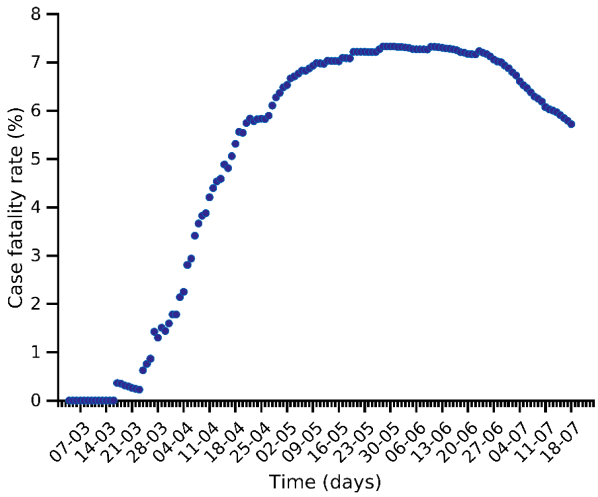


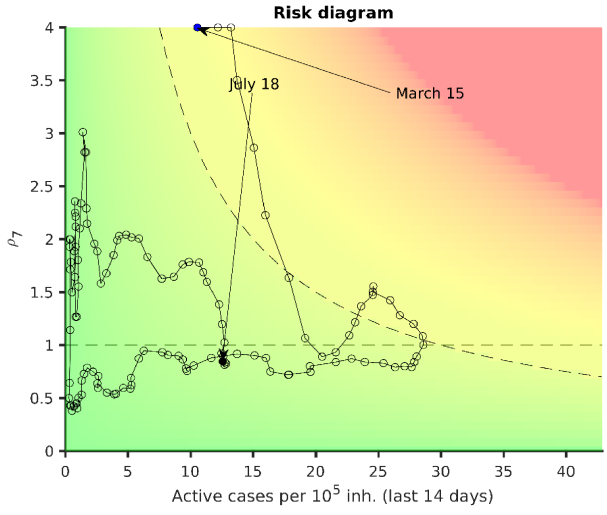


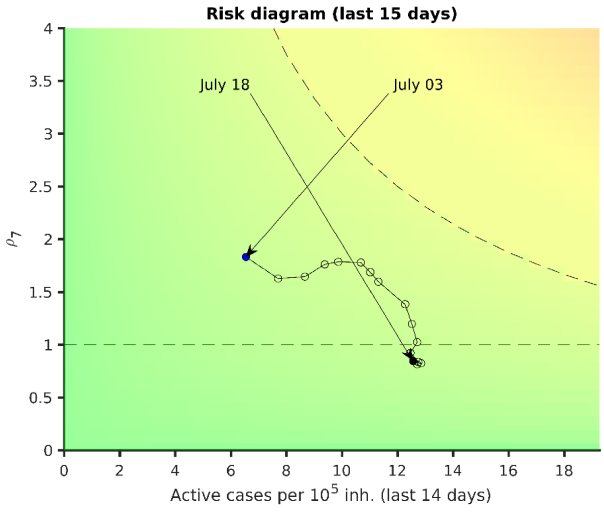




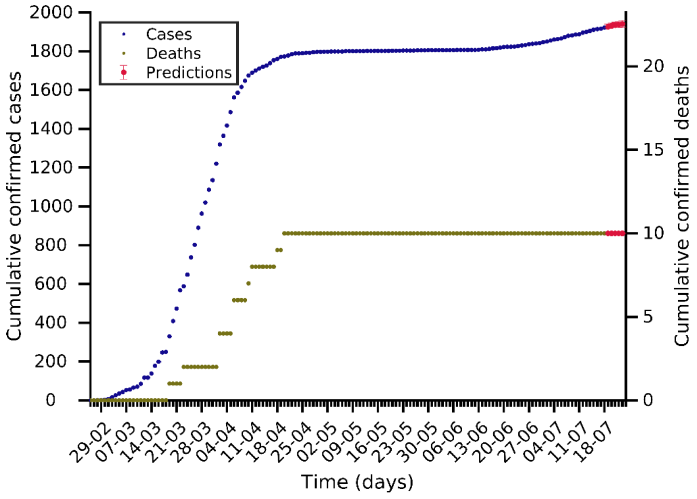


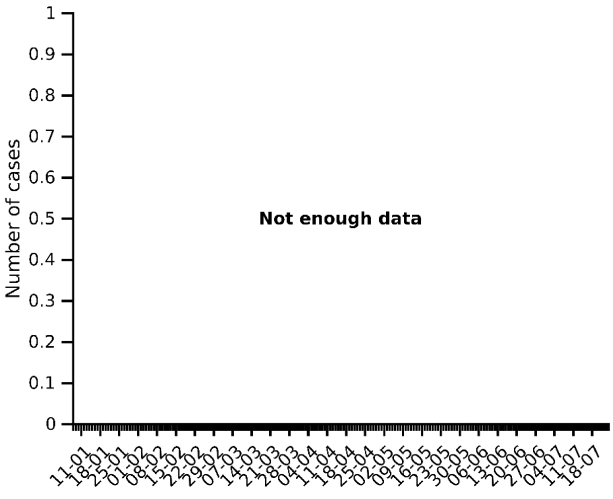


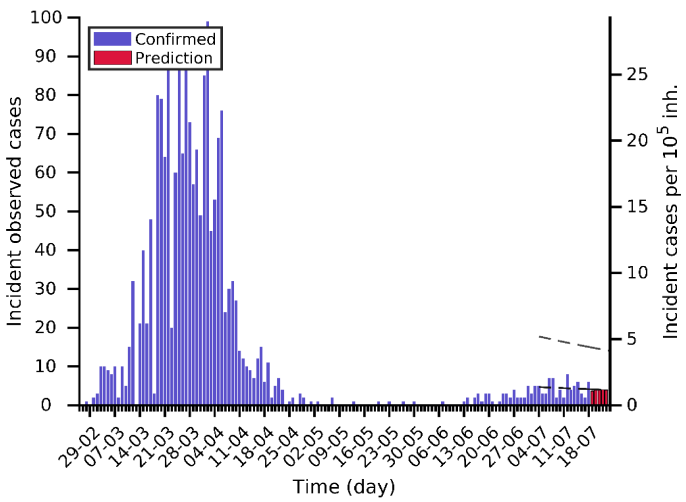


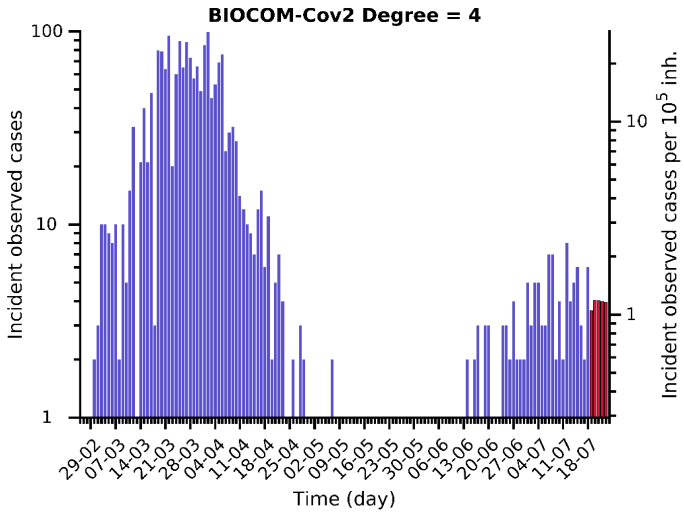


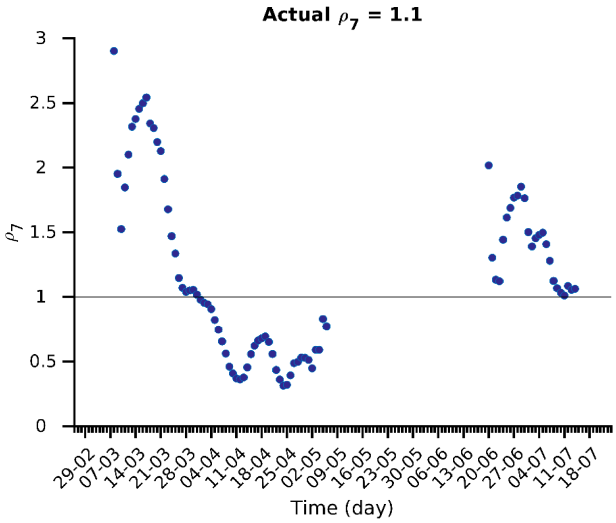
Iceland 18-07-2020. Pop: 0.3M. Cumulative incidence: 563/10⁵

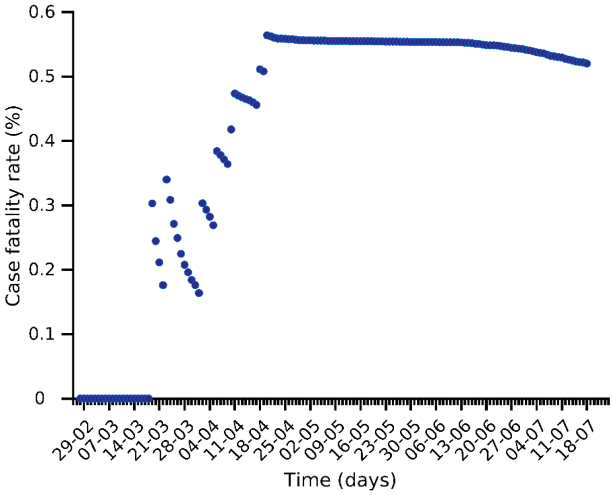


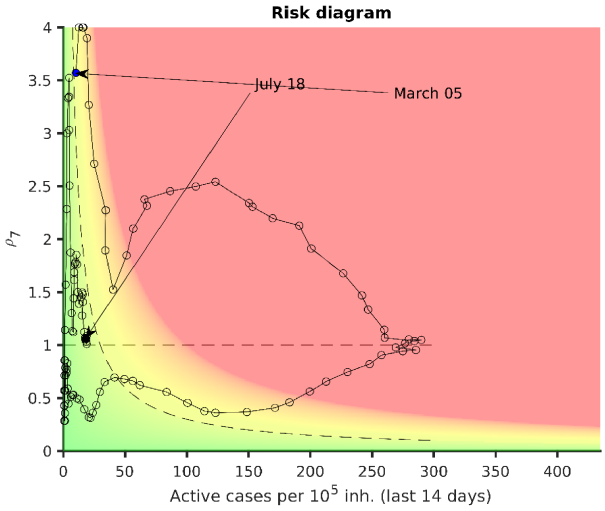


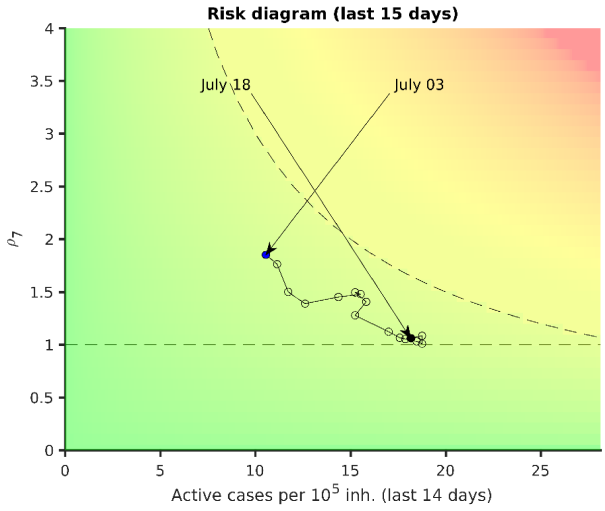




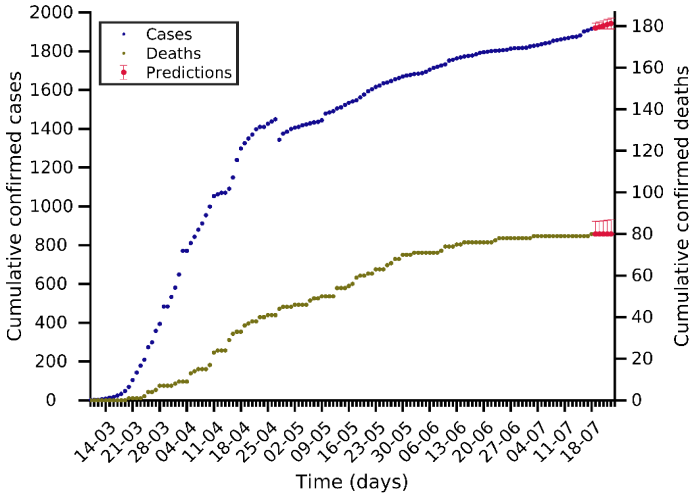


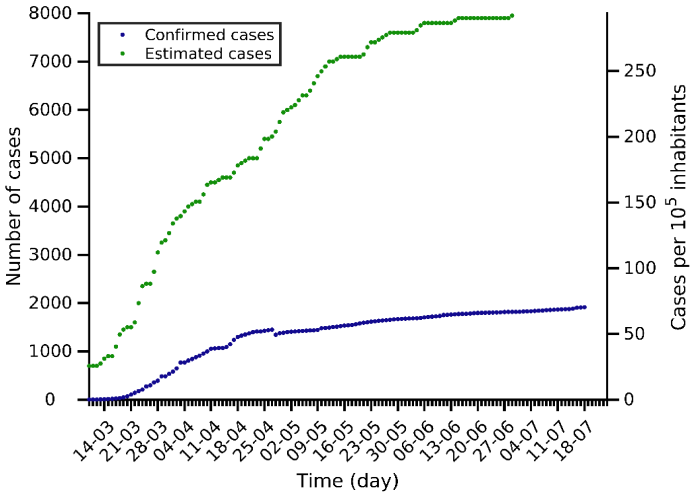


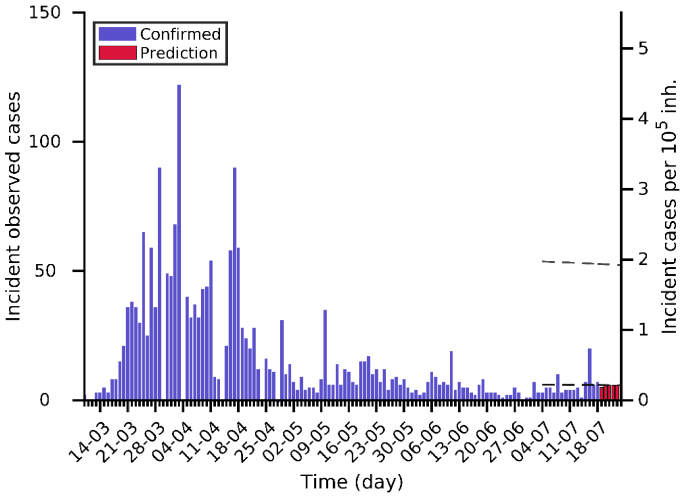


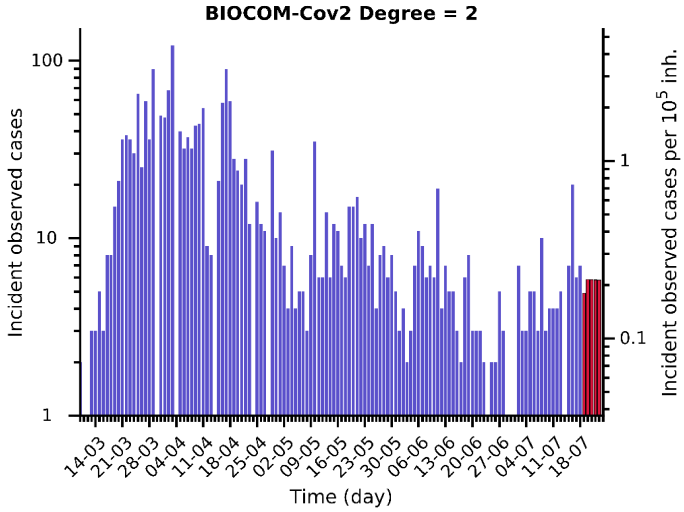


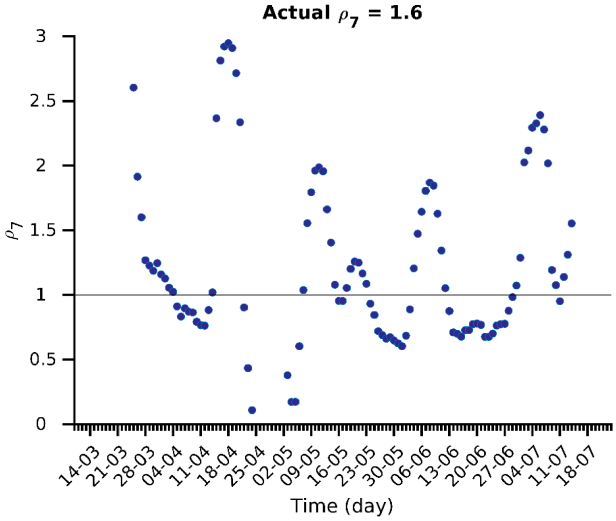
Lithuania 18-07-2020. Pop: 2.7M. Cumulative incidence: 70/10⁵

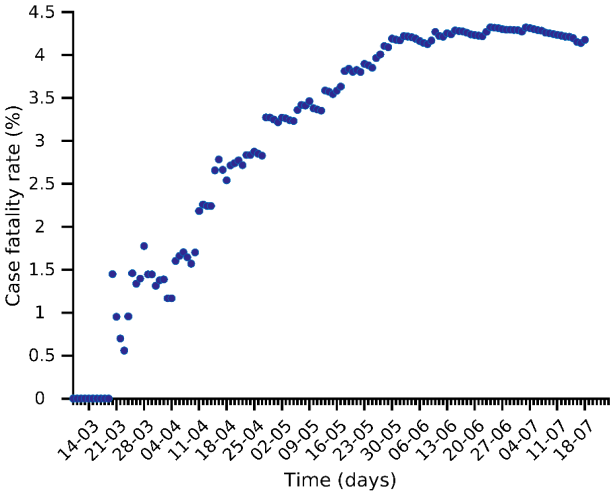


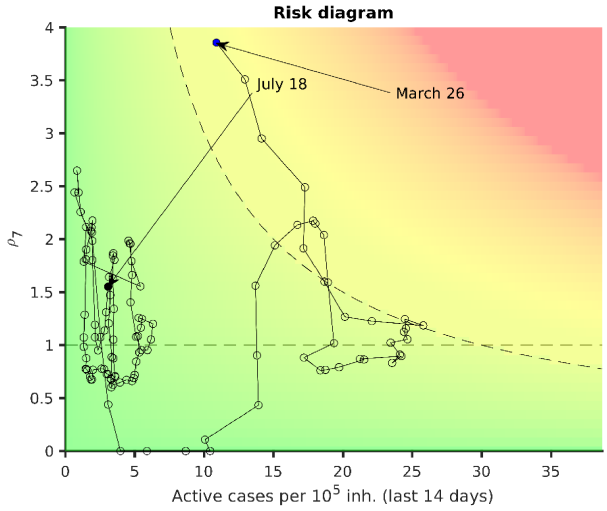


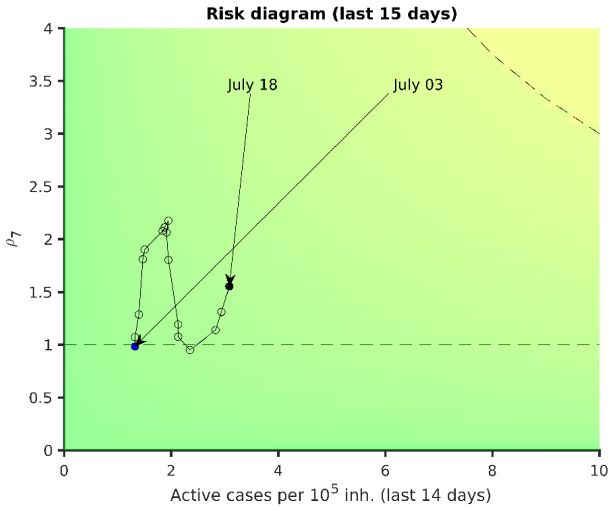




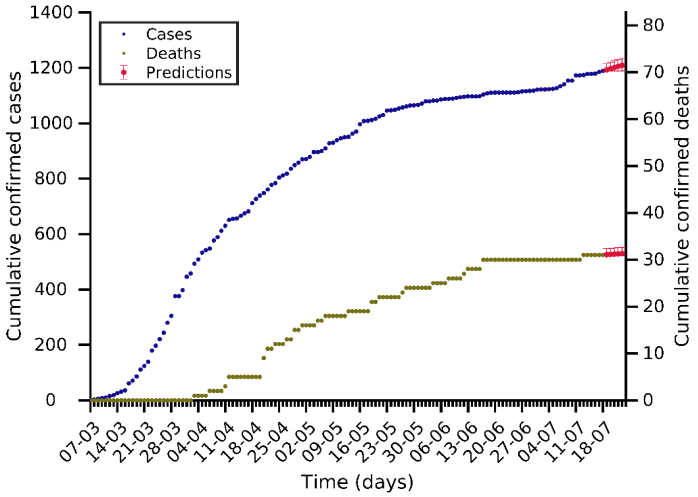


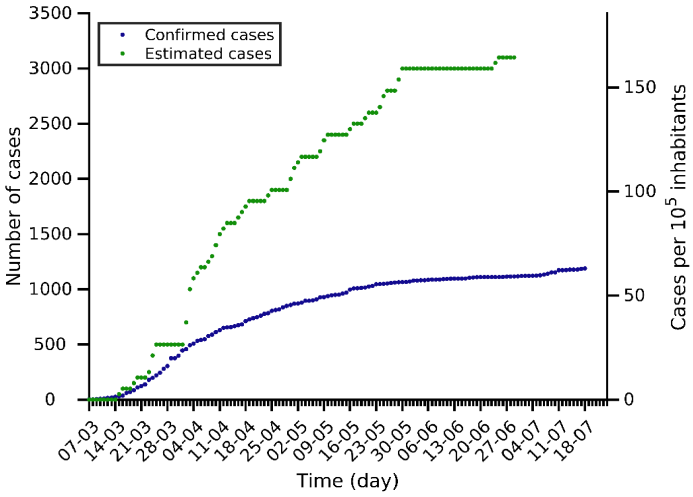


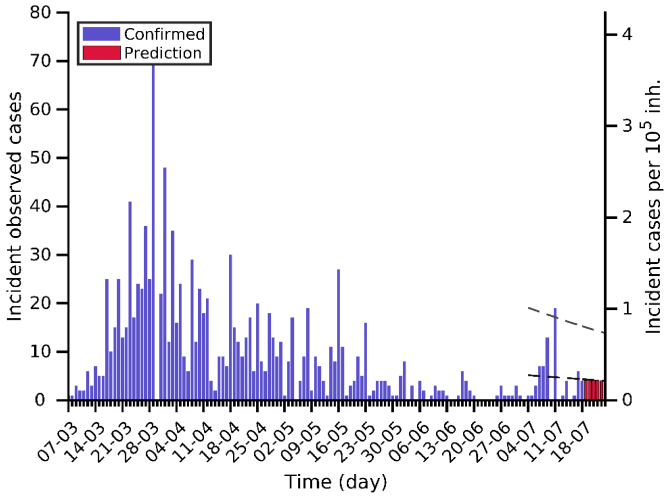


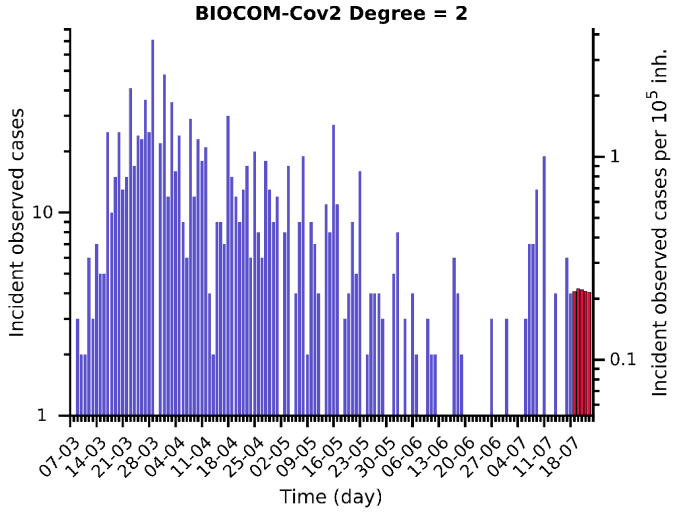


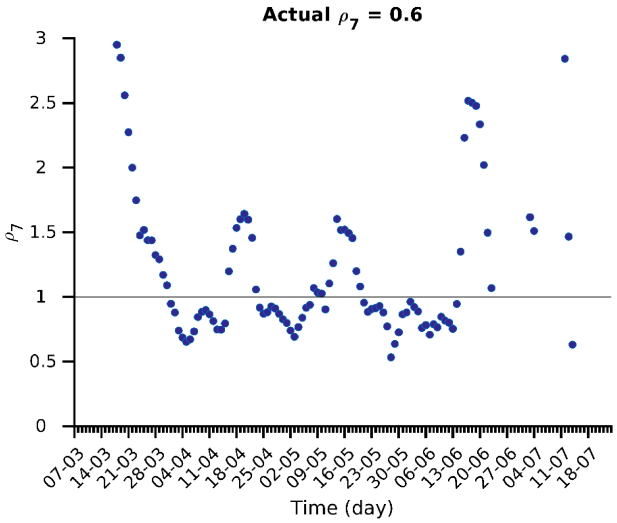
Latvia 18-07-2020. Pop: 1.9M. Cumulative incidence: 63/10⁵

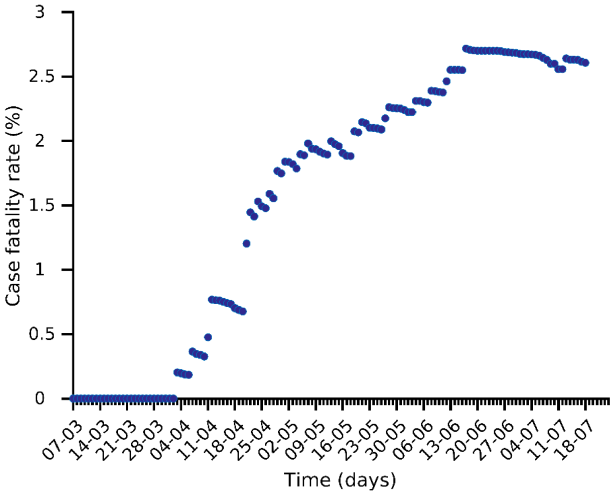


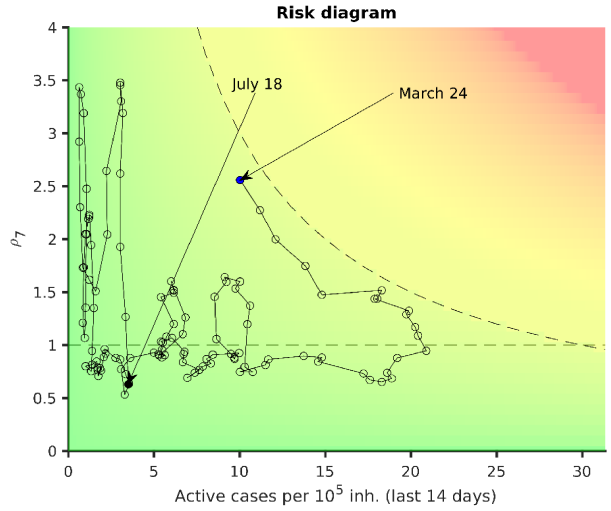


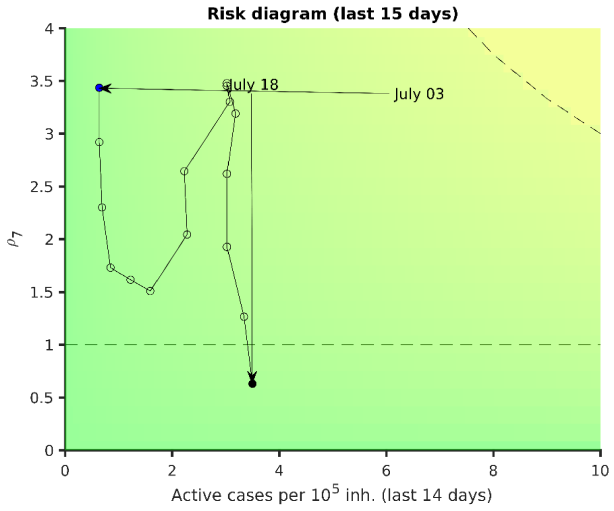




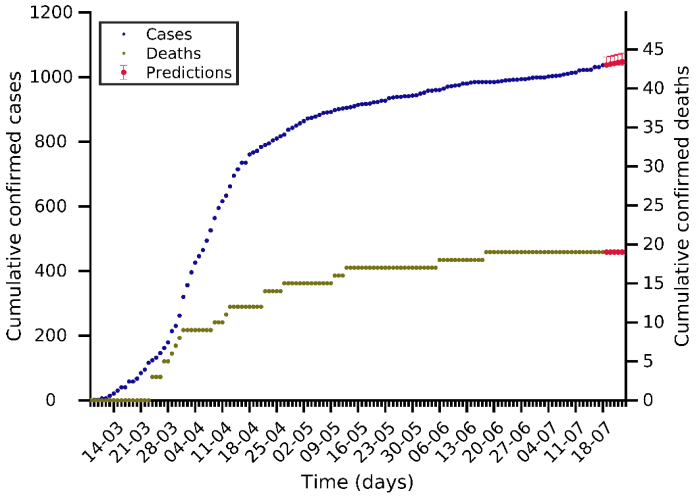


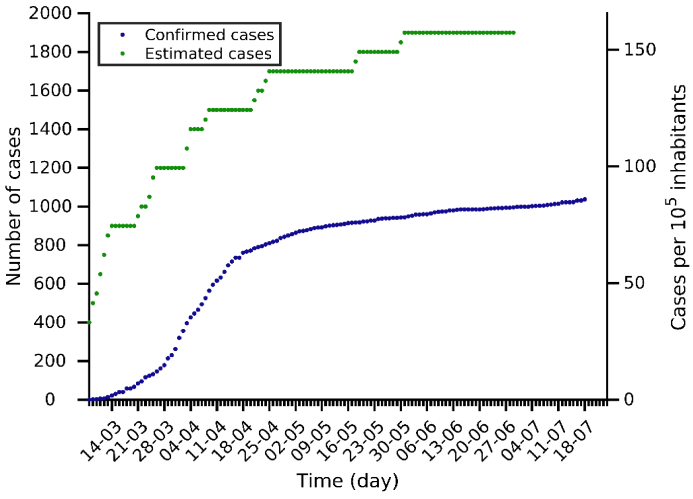


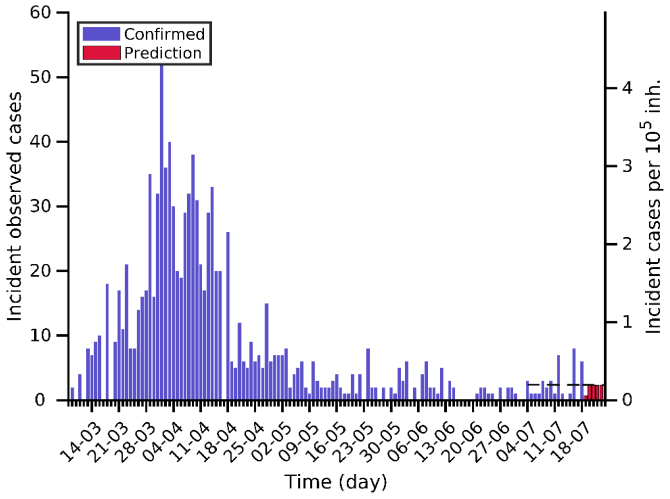


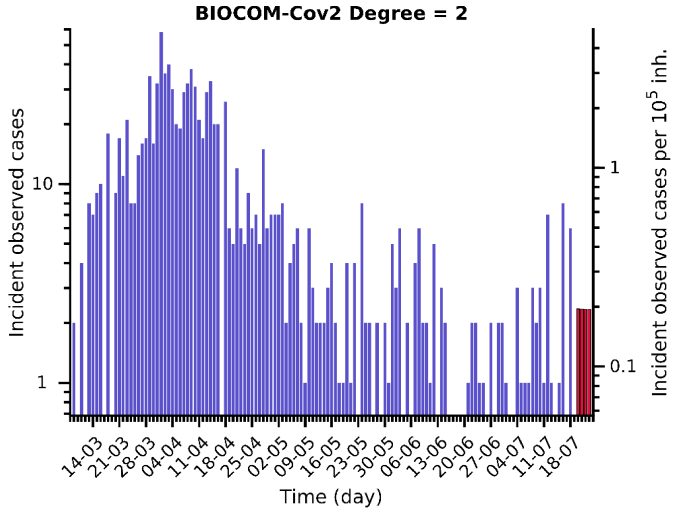


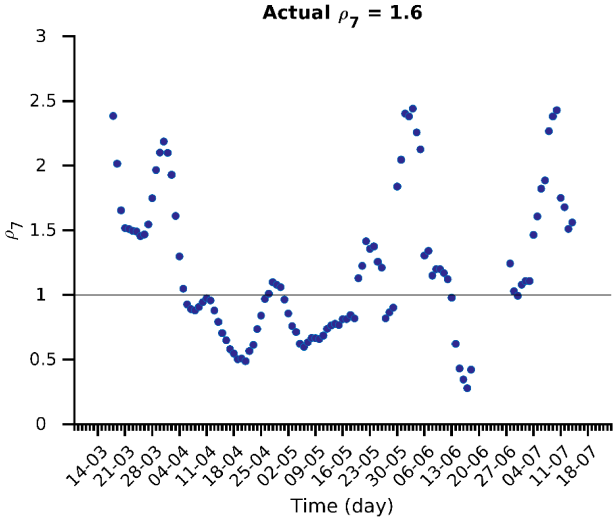
Cyprus 18-07-2020. Pop: 1.2M. Cumulative incidence: 86/10^5

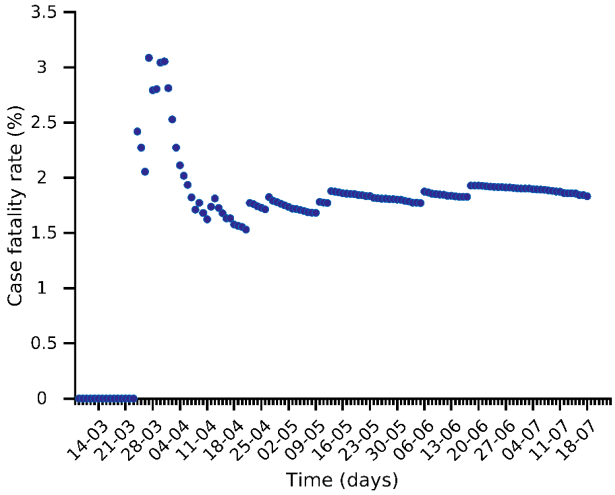


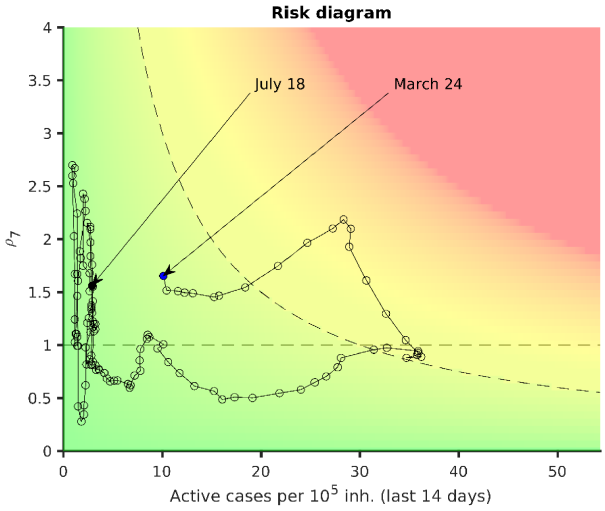


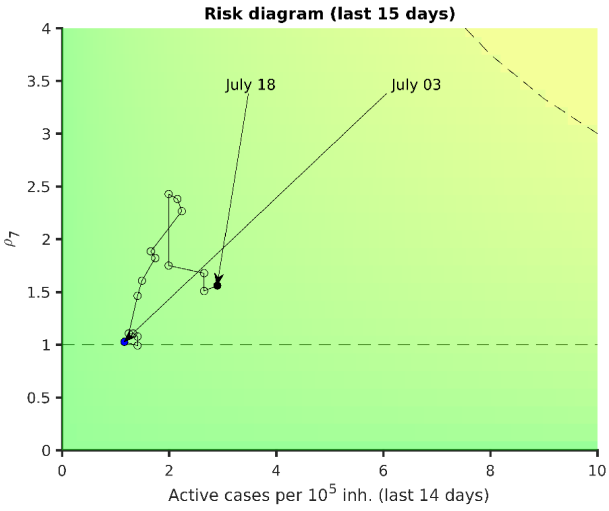




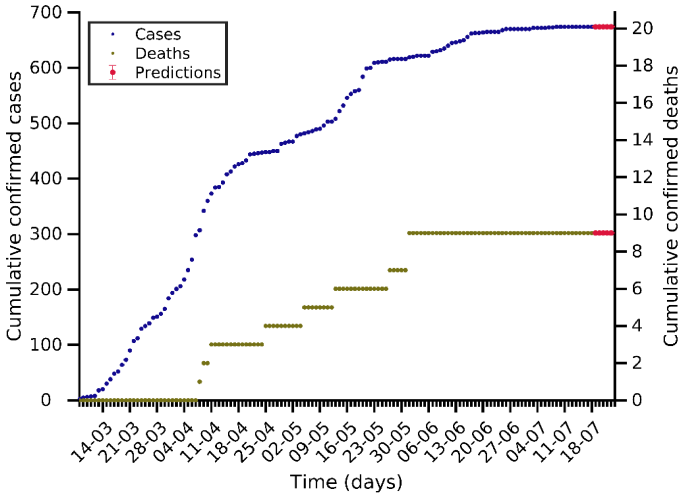


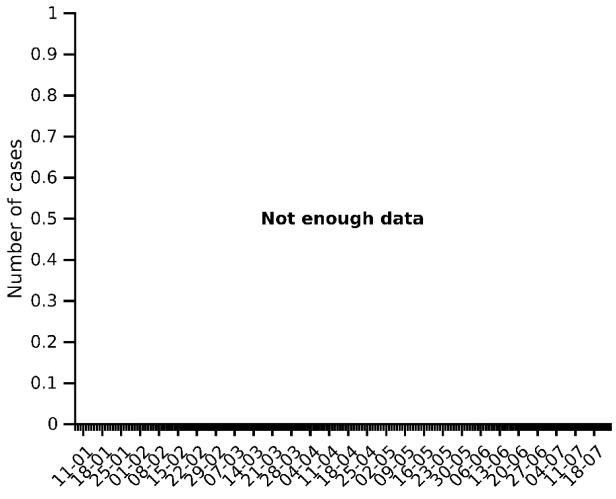


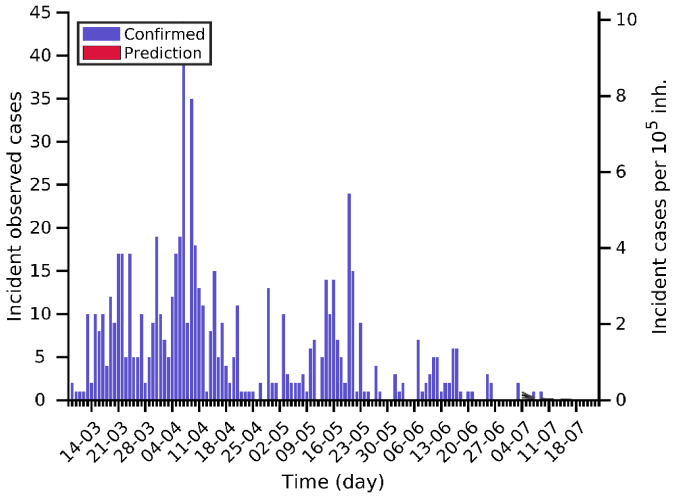


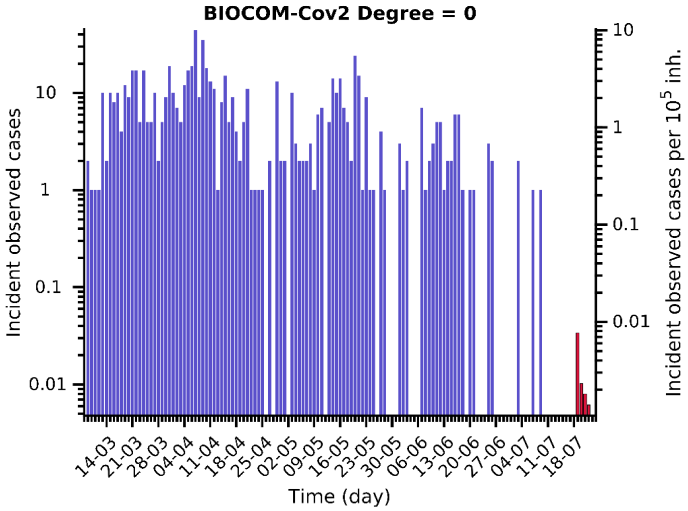


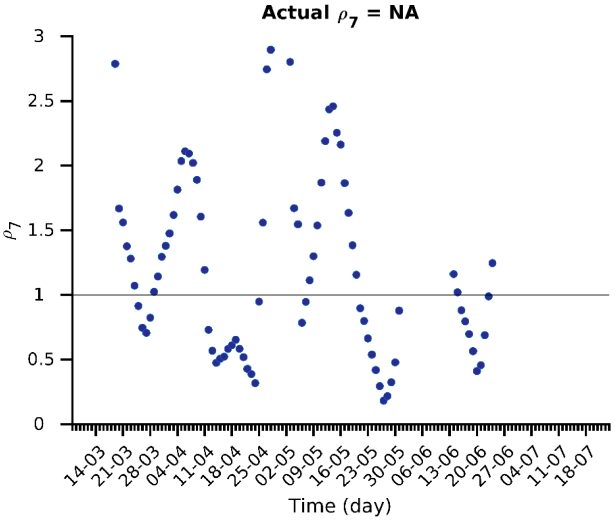
Malta 18-07-2020. Pop: 0.4M. Cumulative incidence: 153/10⁵

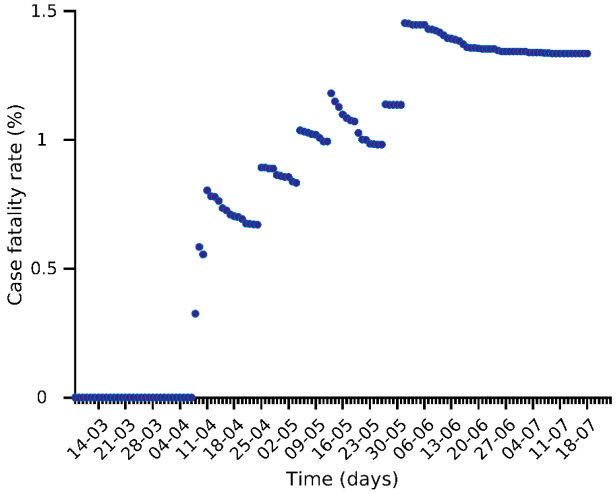


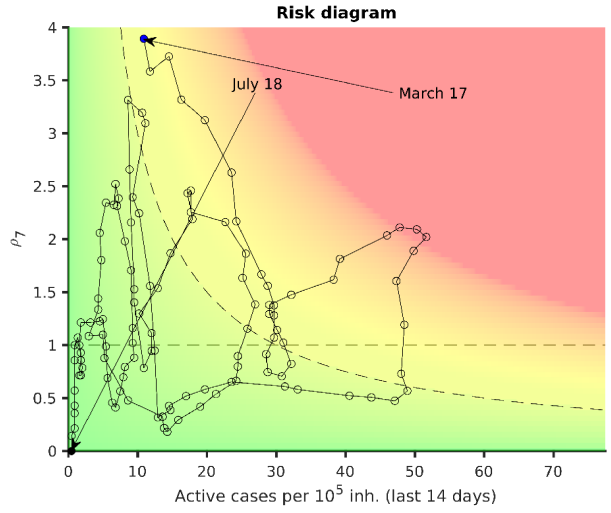


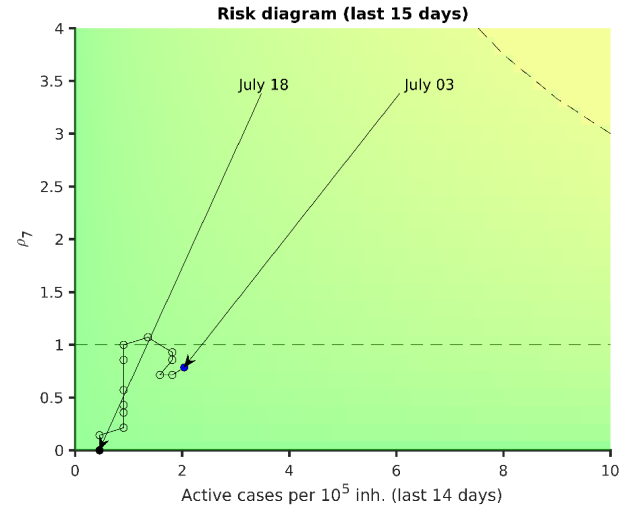








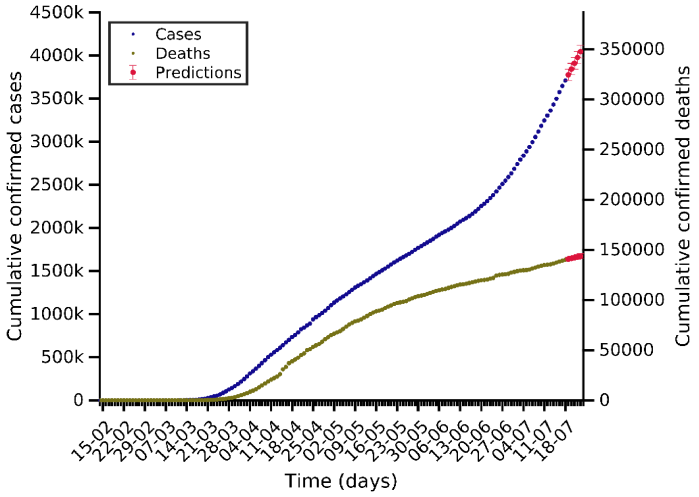


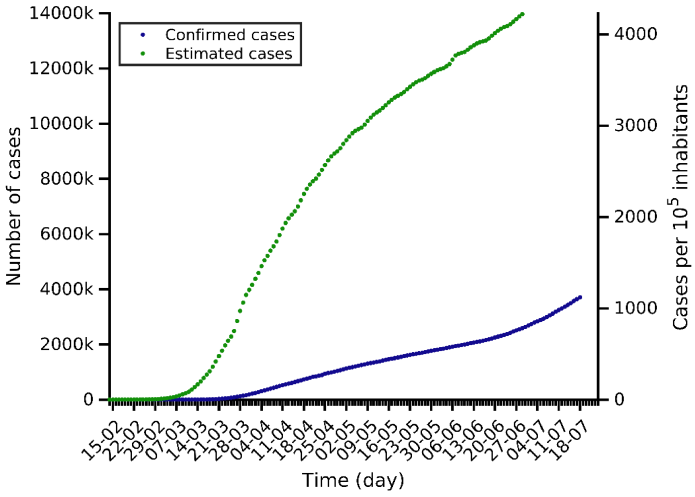


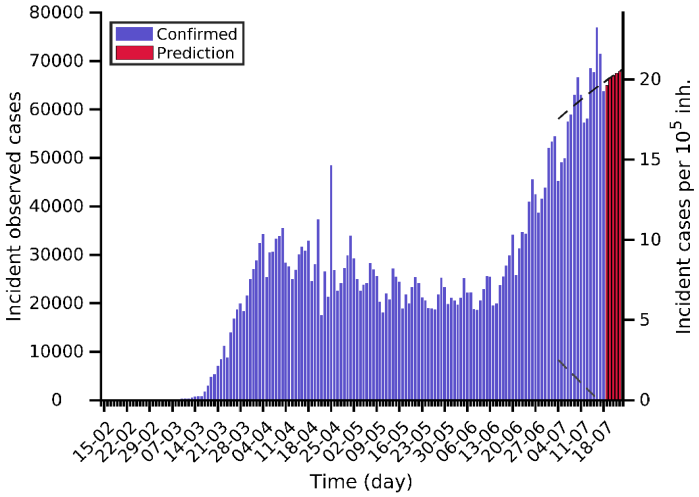
(2) Analysis and prediction of COVID-19 for other countries

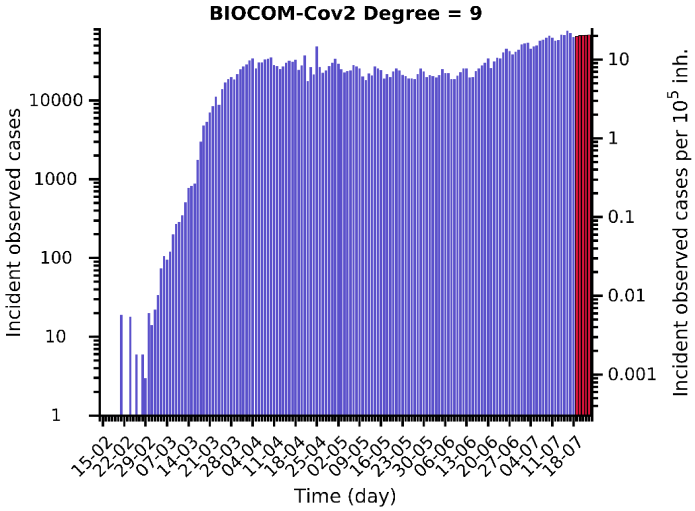
Data obtained from https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases

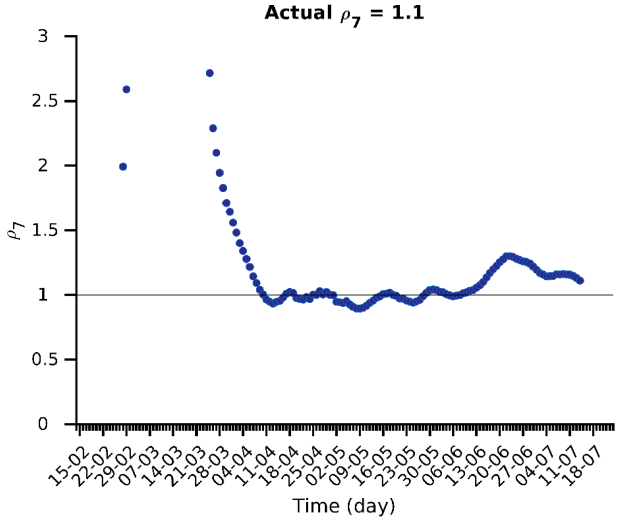
USA 18-07-2020. Pop: 331.0M. Cumulative incidence: 1121/10⁵

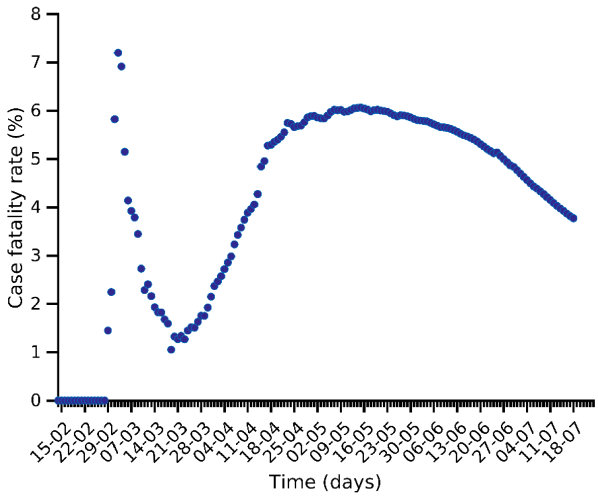


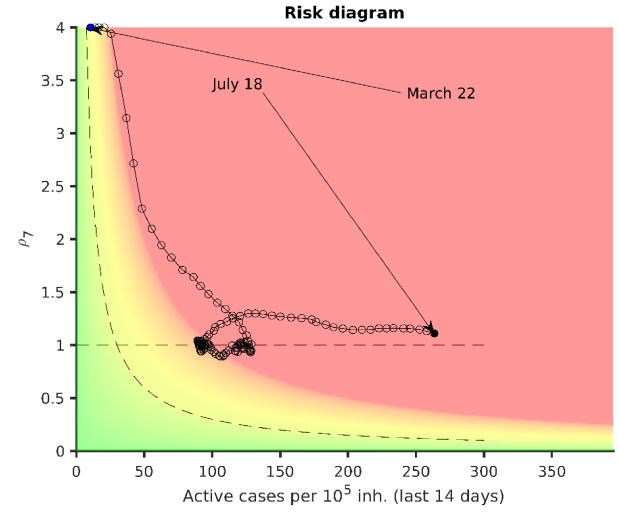


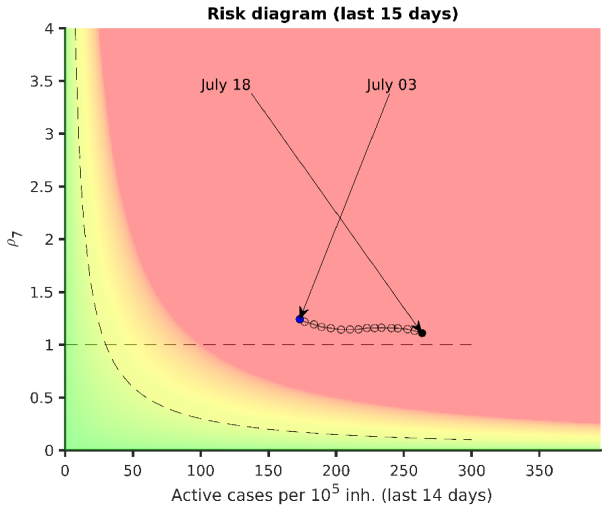




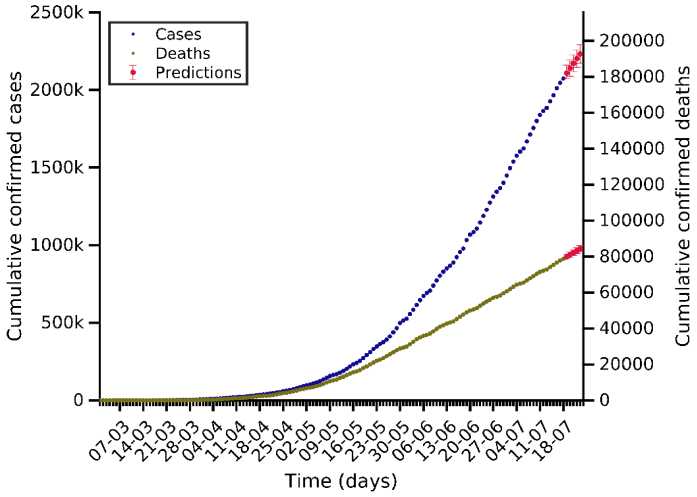


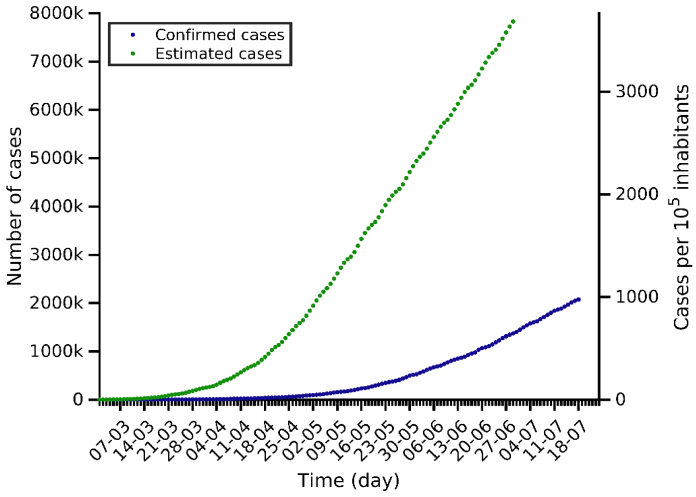


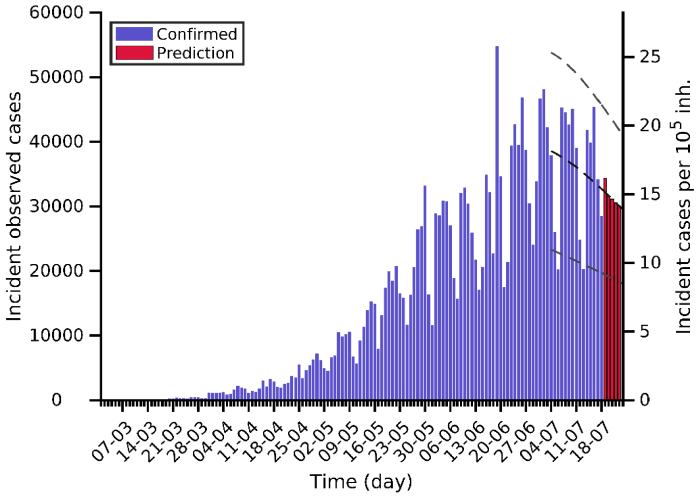


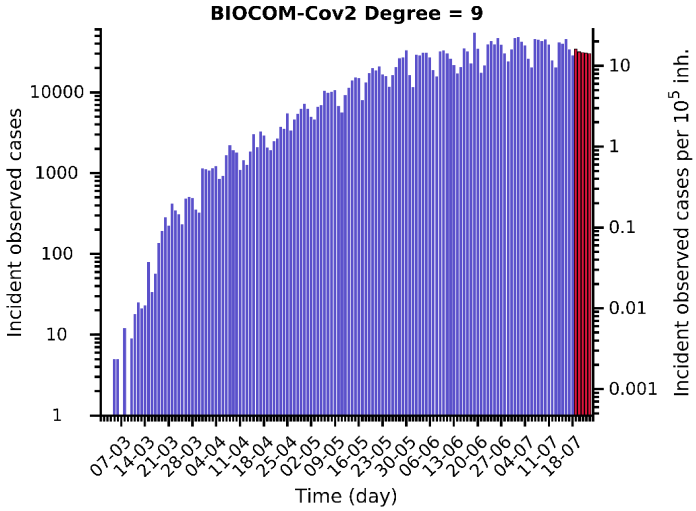


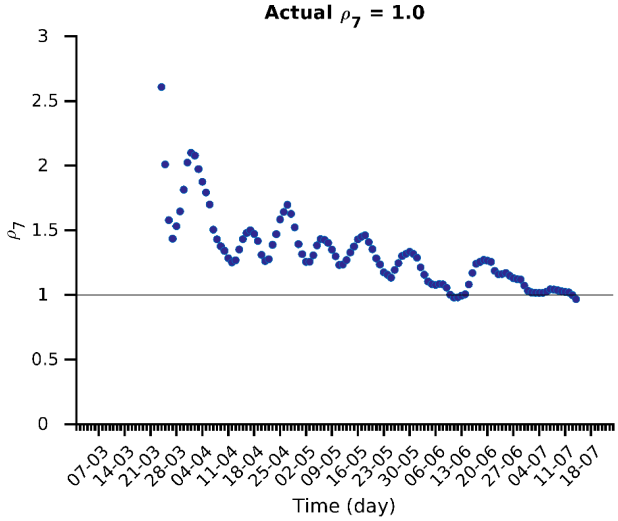
Brazil 18-07-2020. Pop: 212.6M. Cumulative incidence: 976/10⁵

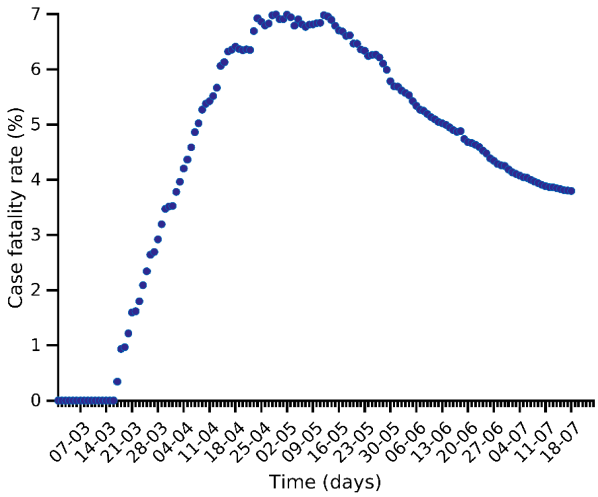


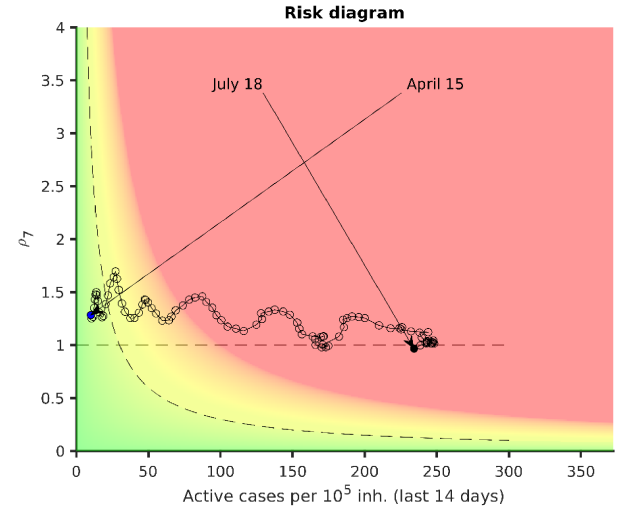


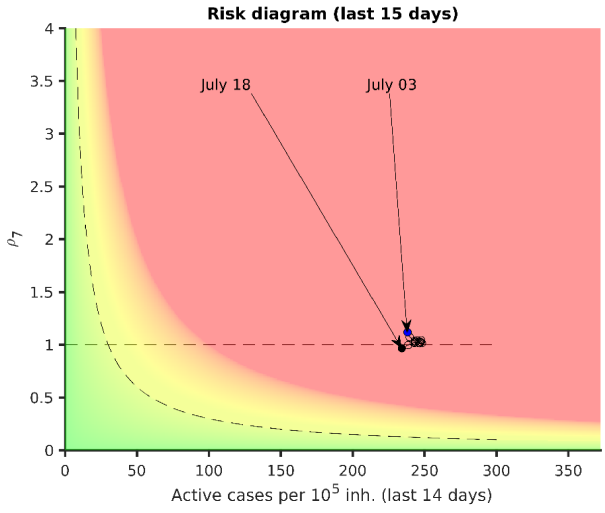




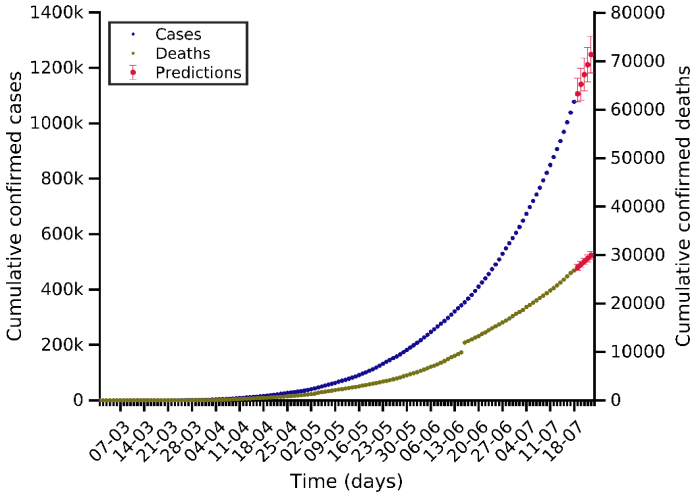


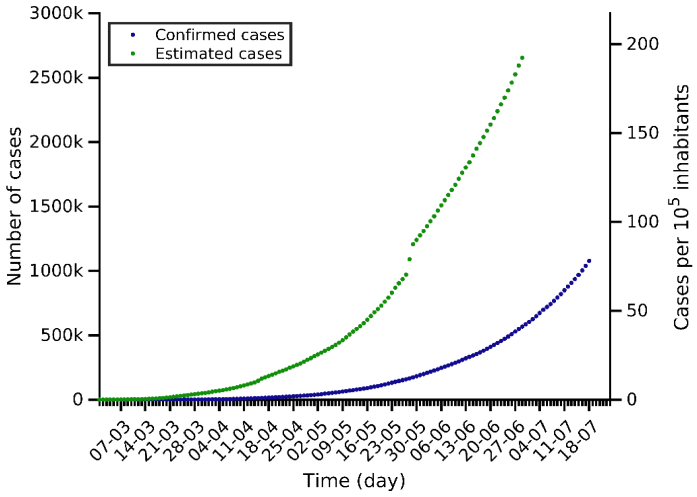


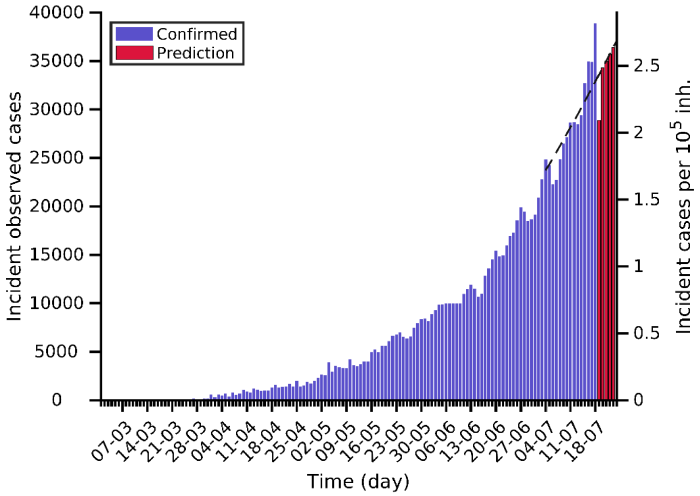


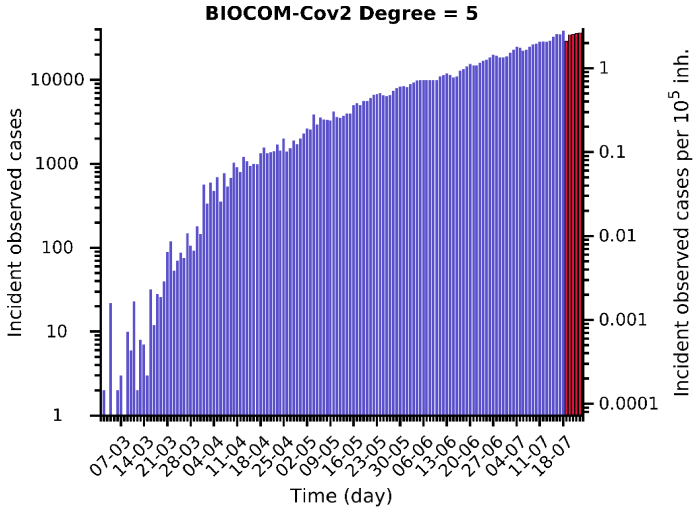


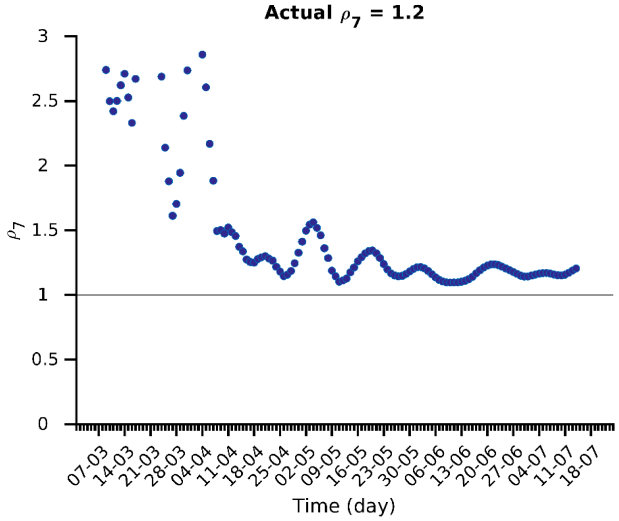
India 18-07-2020. Pop: 1380.0M. Cumulative incidence: 78/10⁵

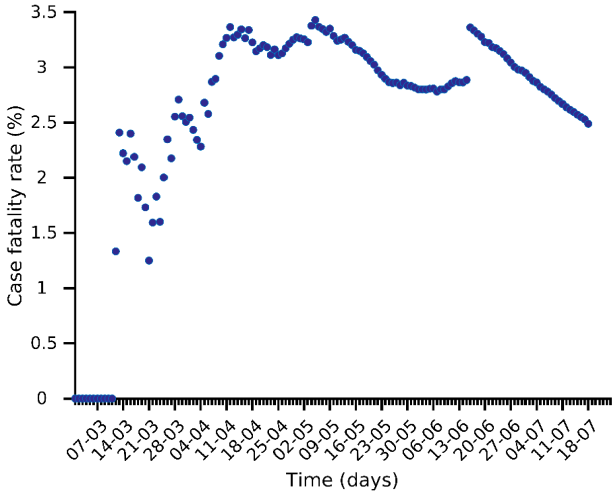


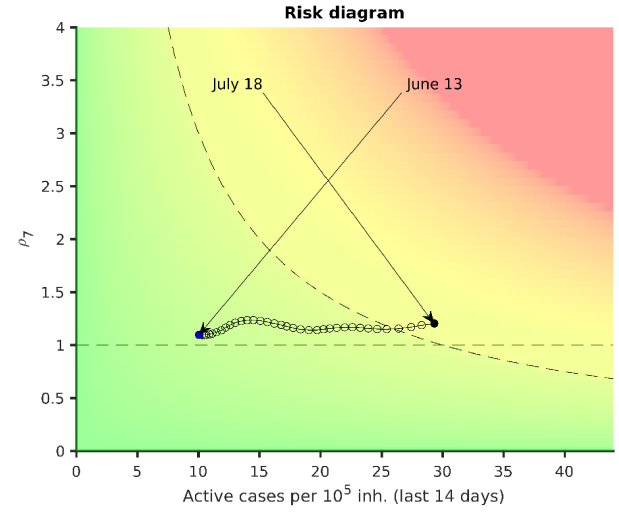


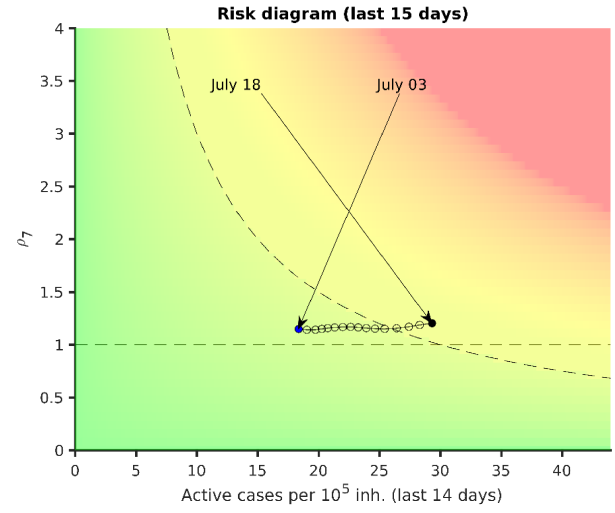




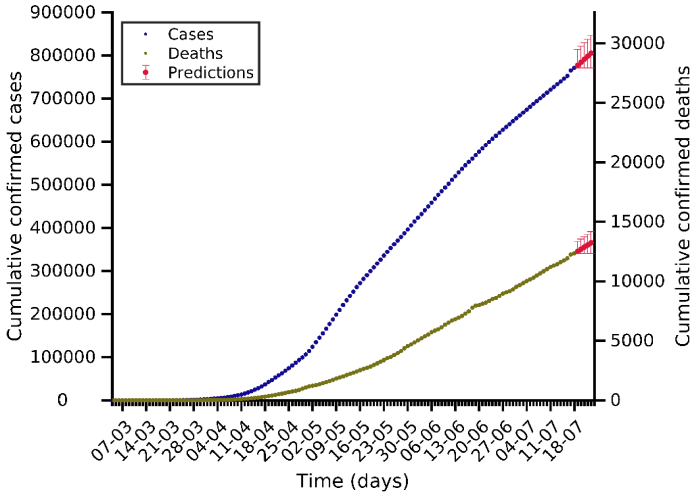


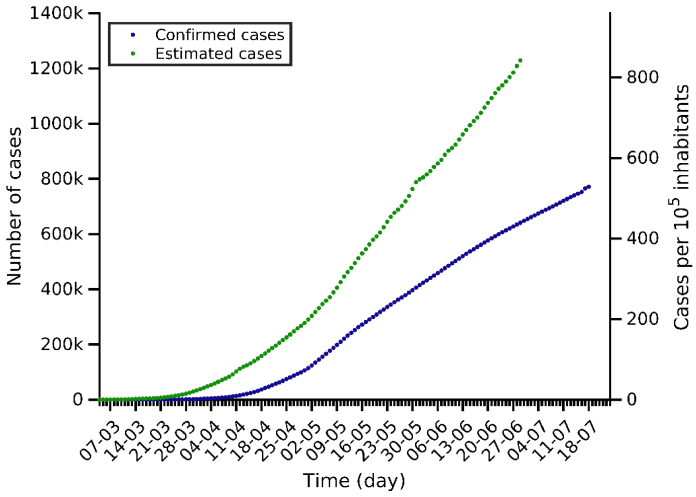


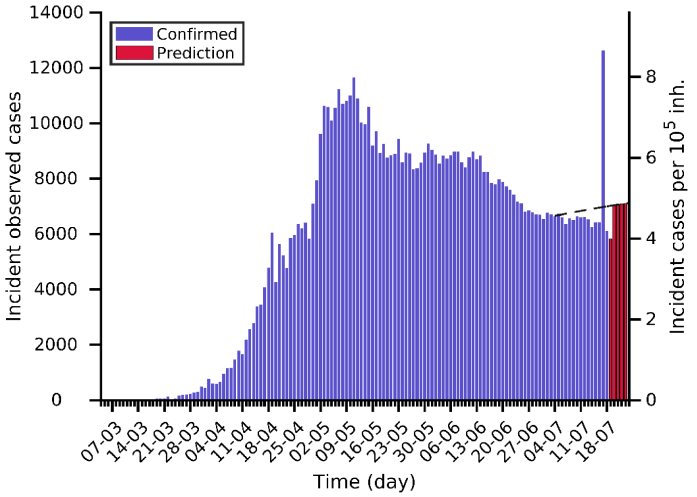


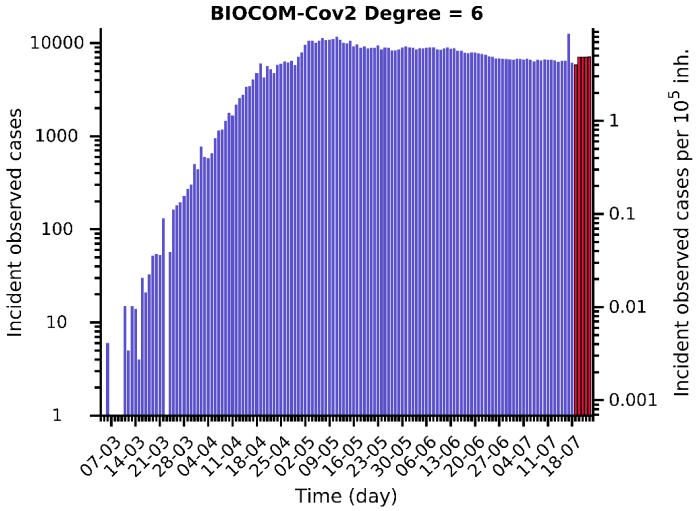


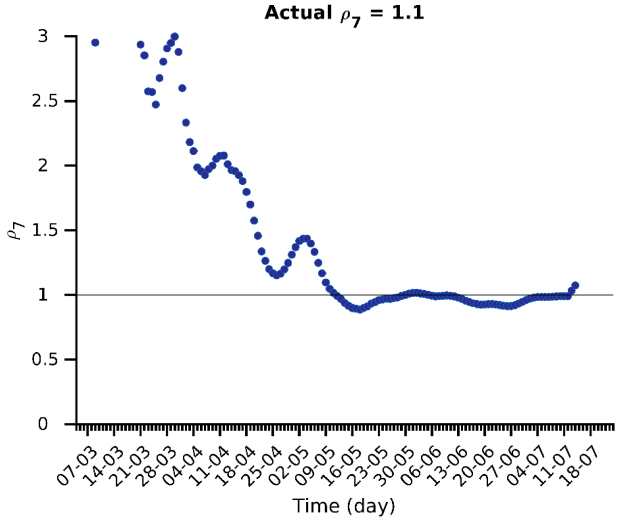
Russia 18-07-2020. Pop: 145.9M. Cumulative incidence: 529/10⁵

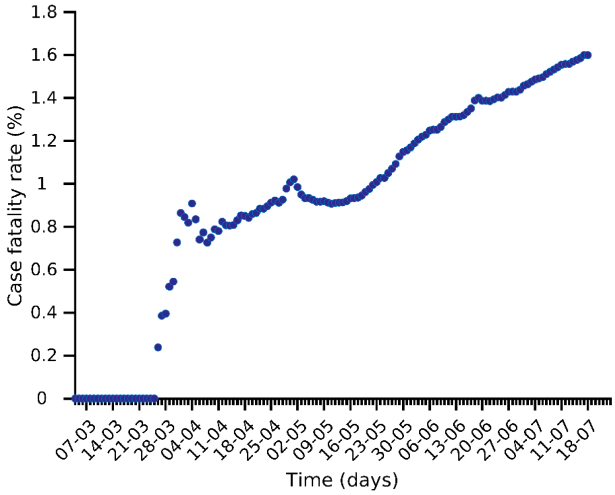


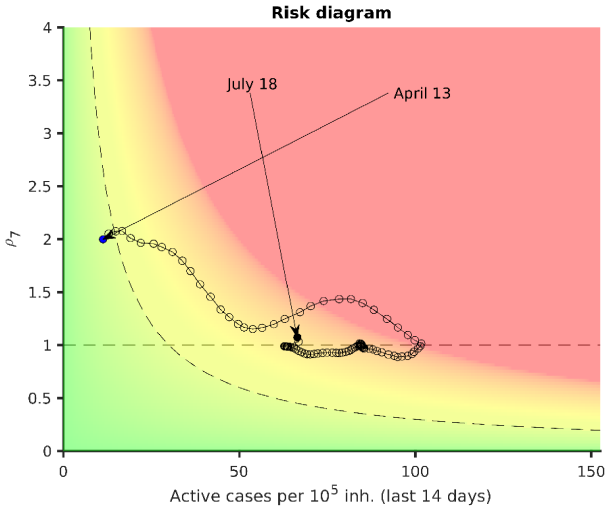


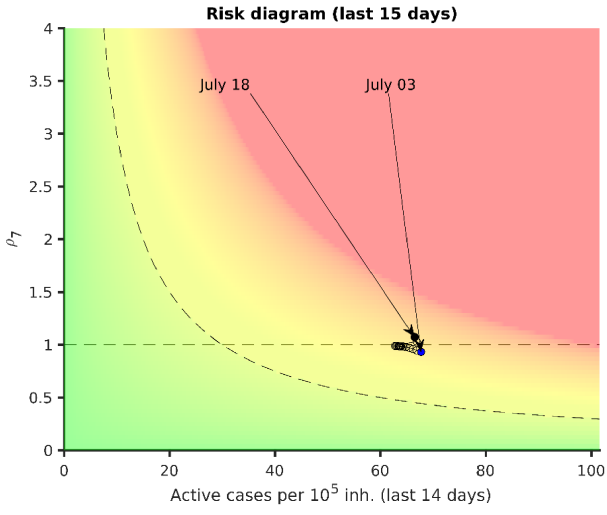




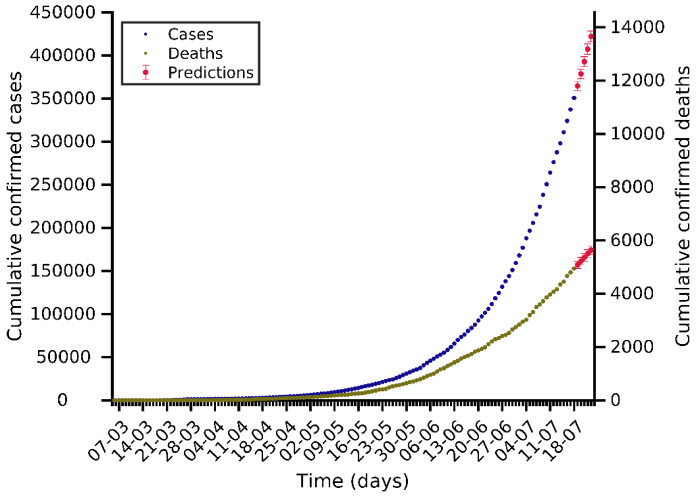


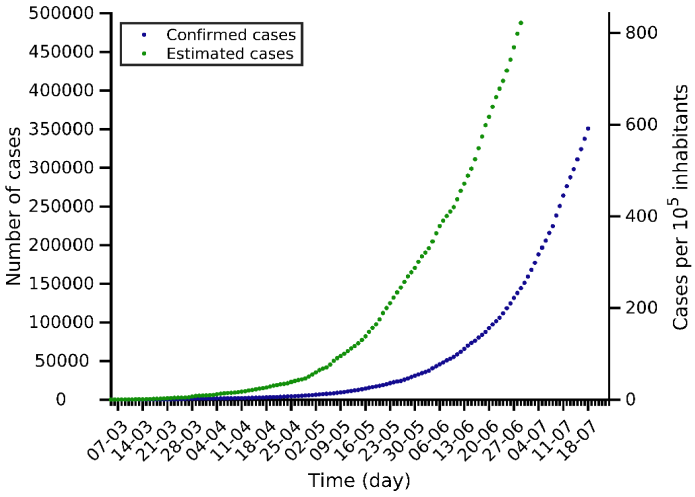


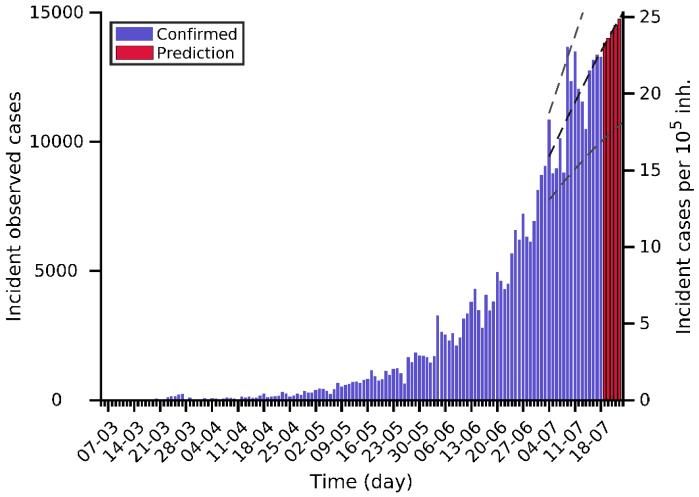


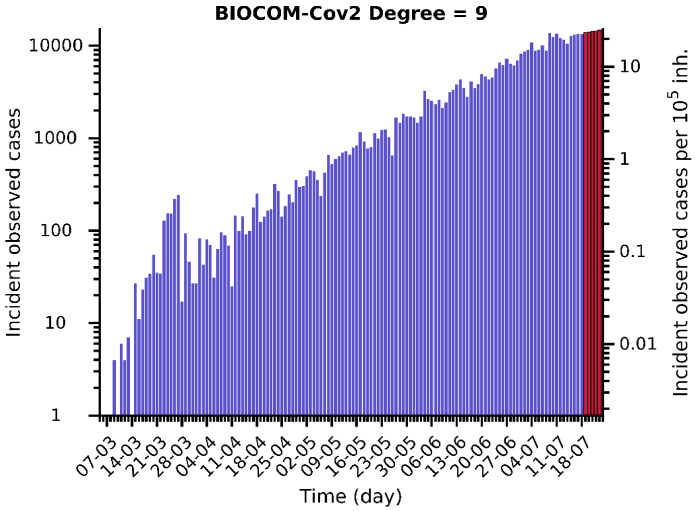


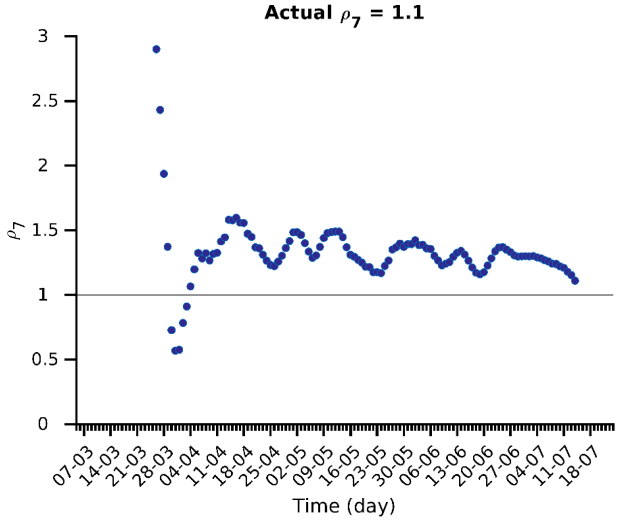
South Africa 18-07-2020. Pop: 59.3M. Cumulative incidence: 592/10⁵

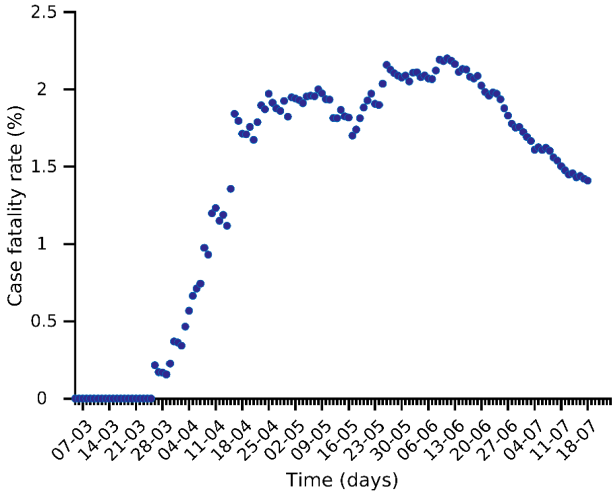


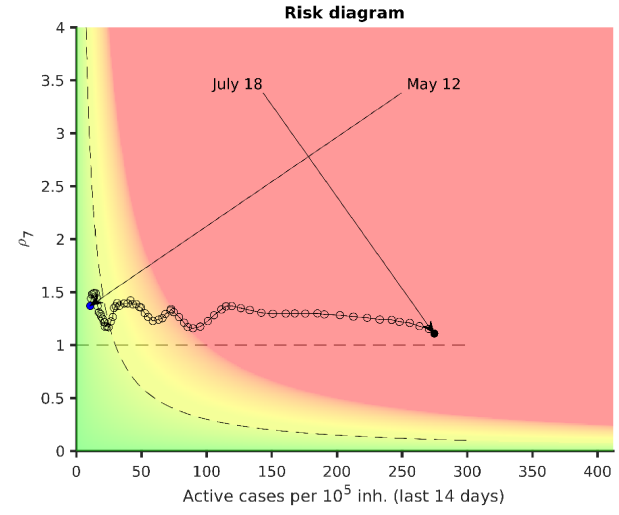


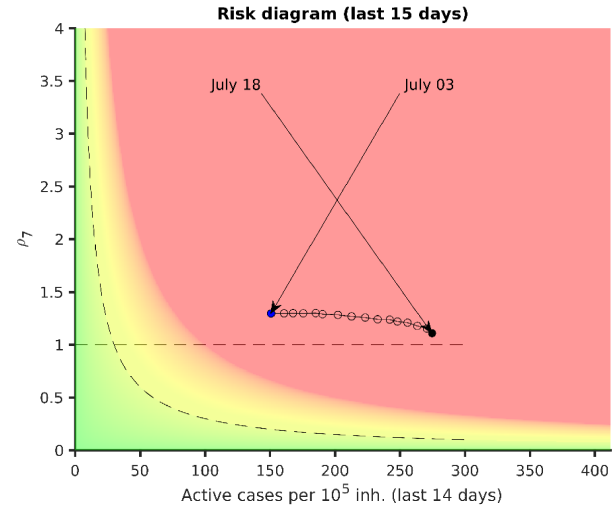




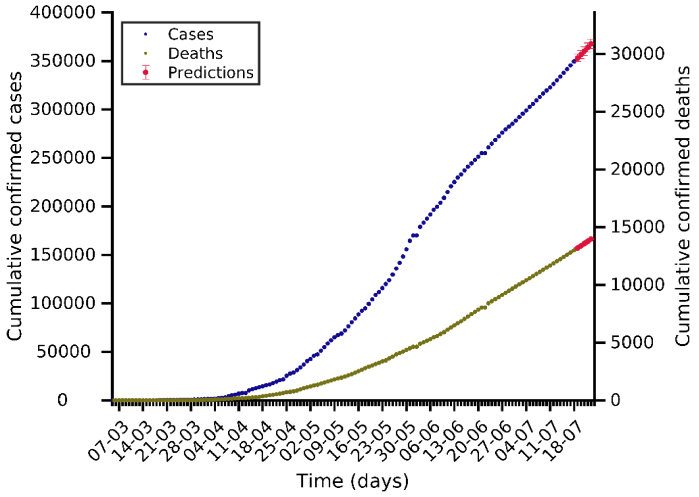


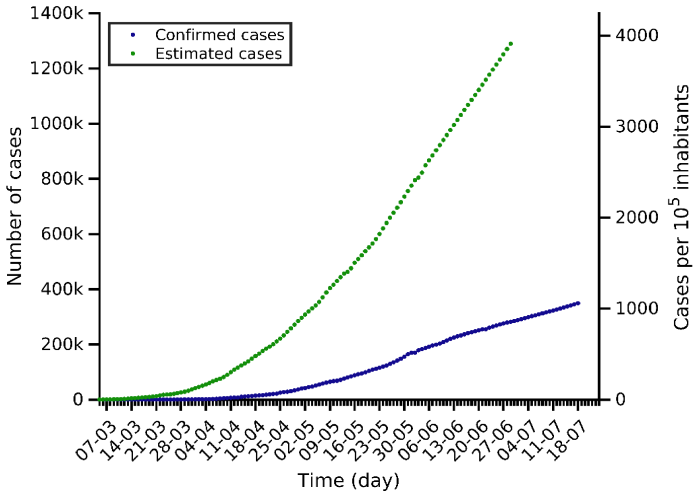


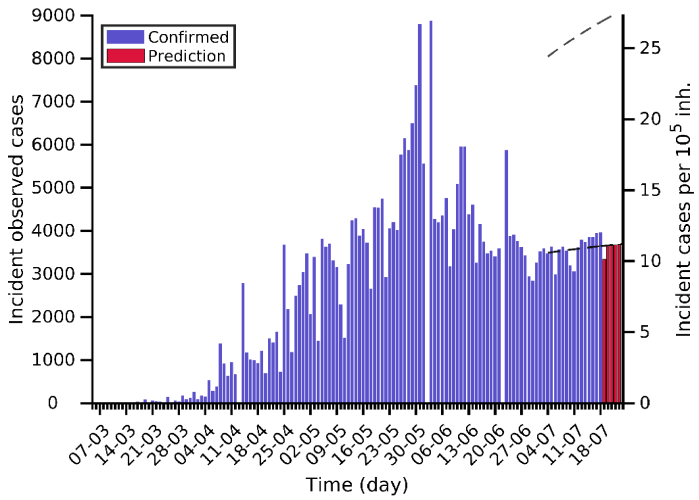


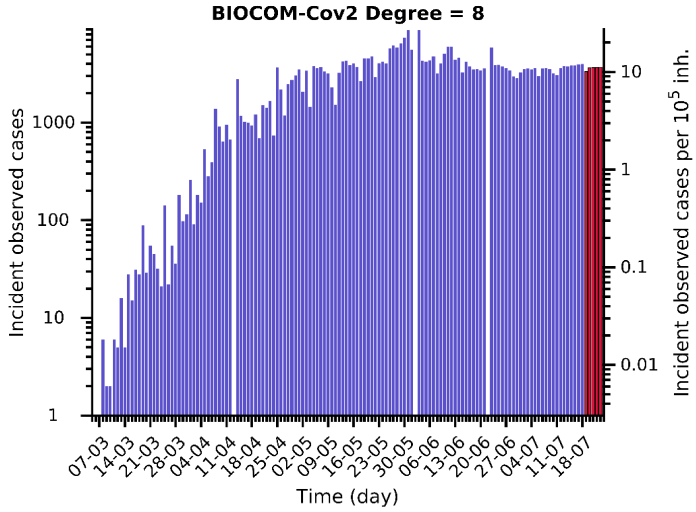


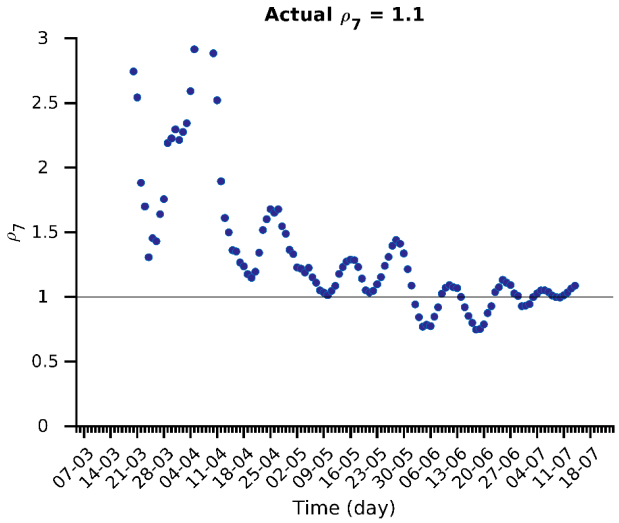
Peru 18-07-2020. Pop: 33.0M. Cumulative incidence: 1060/10⁵

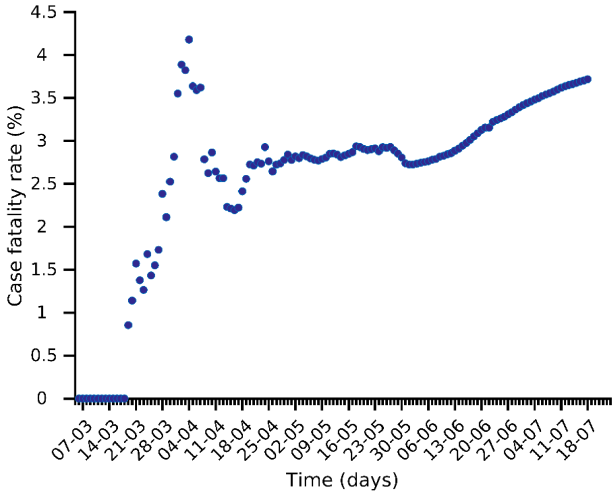


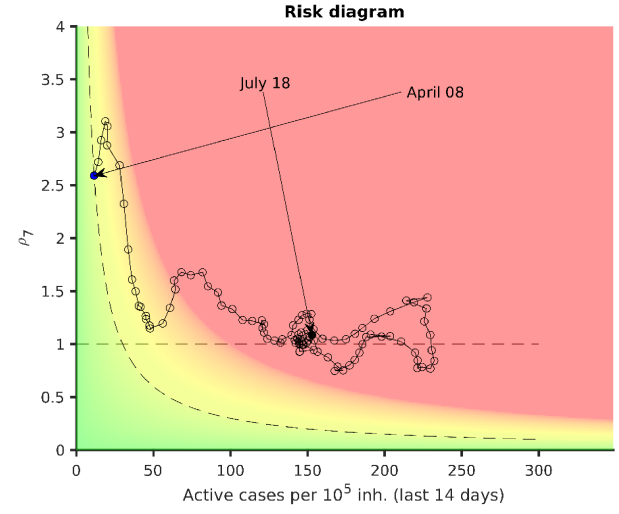


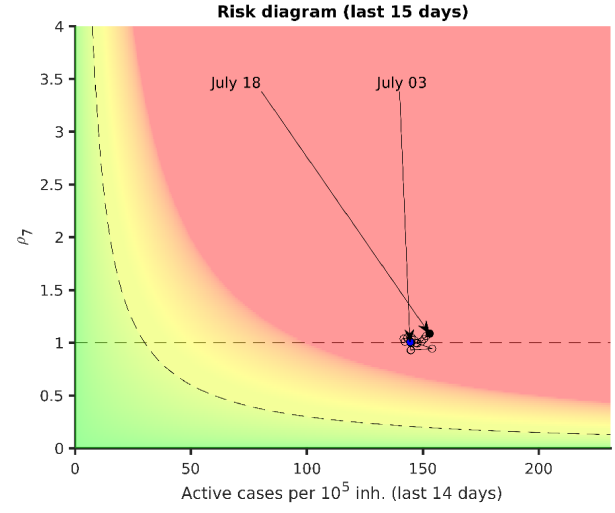




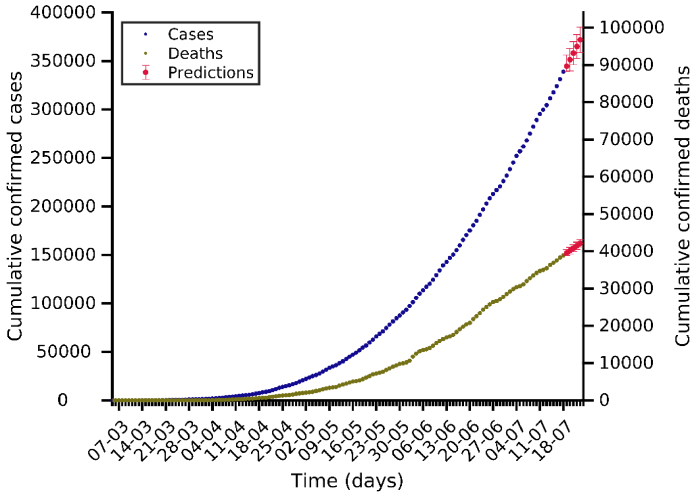


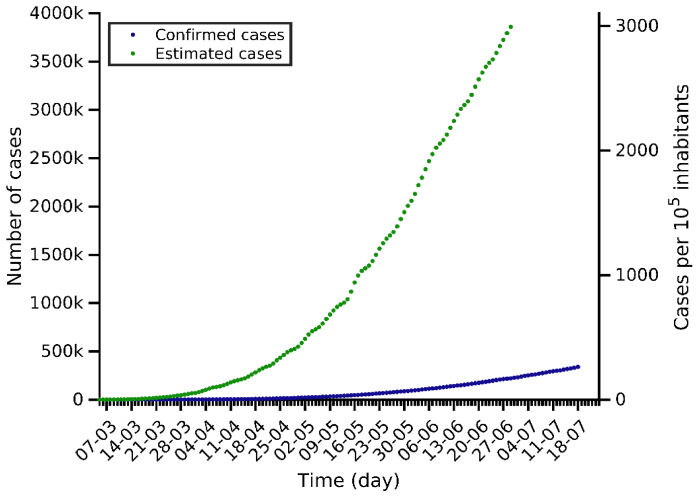


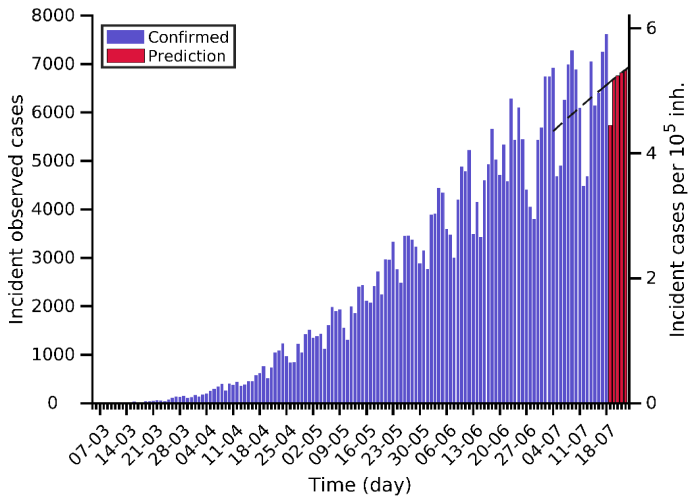


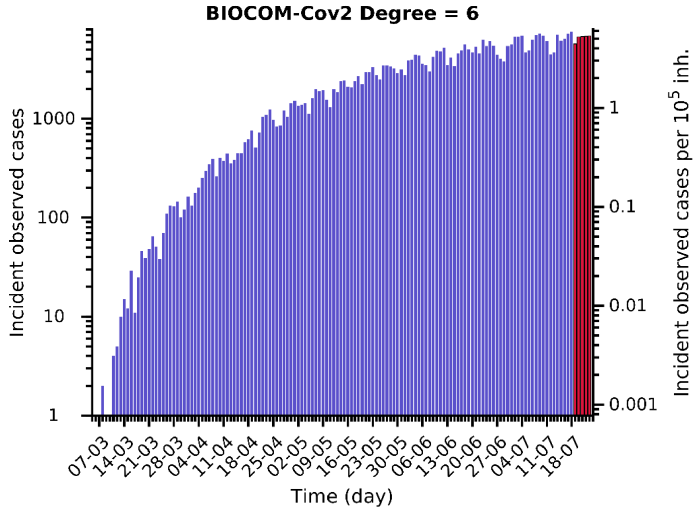


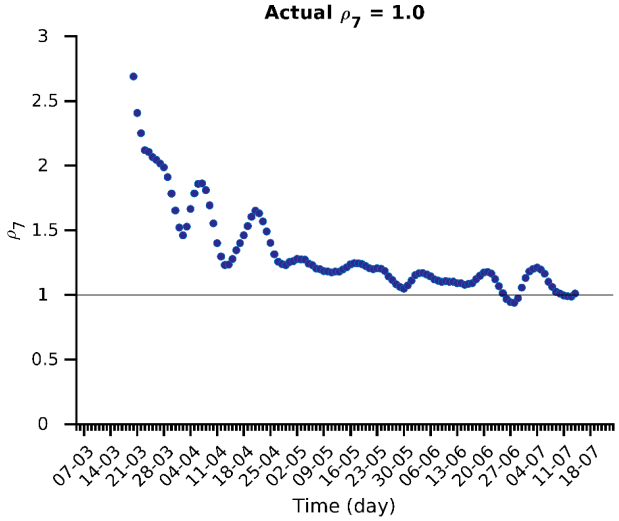
Mexico 18-07-2020. Pop: 128.9M. Cumulative incidence: 263/10⁵

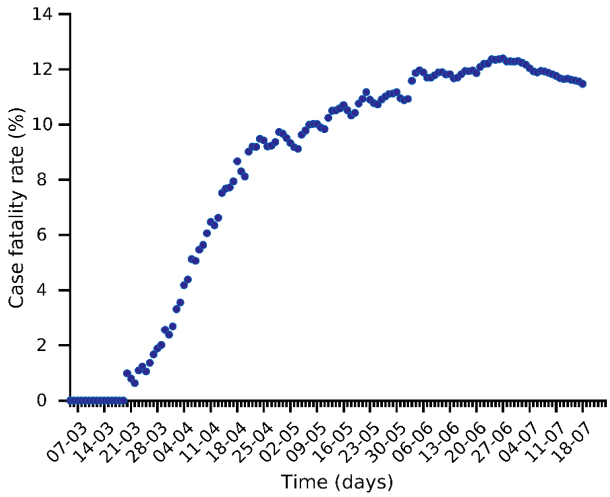


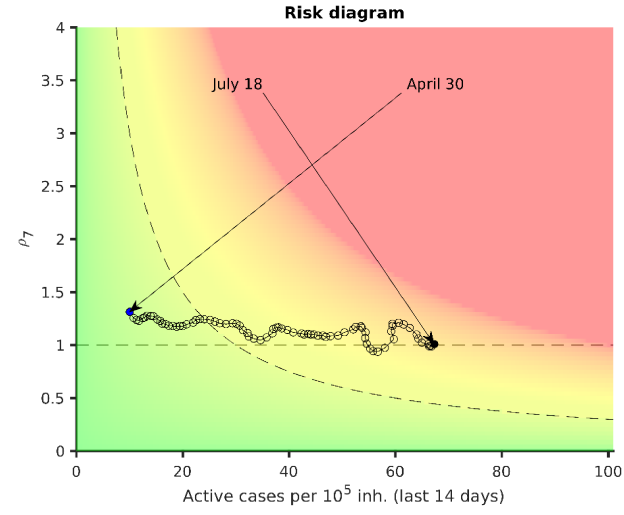


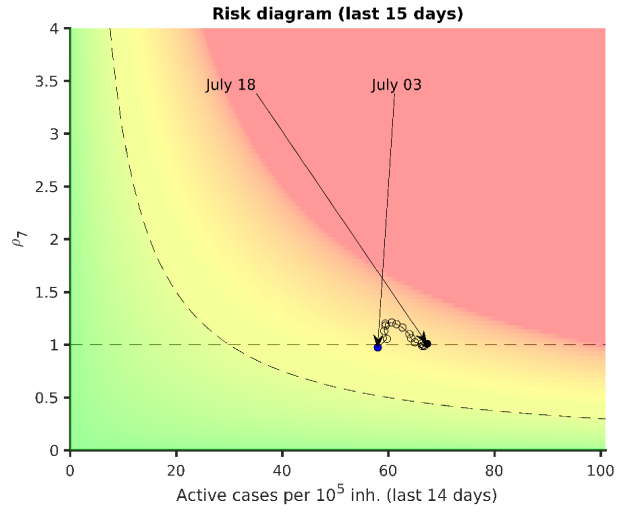




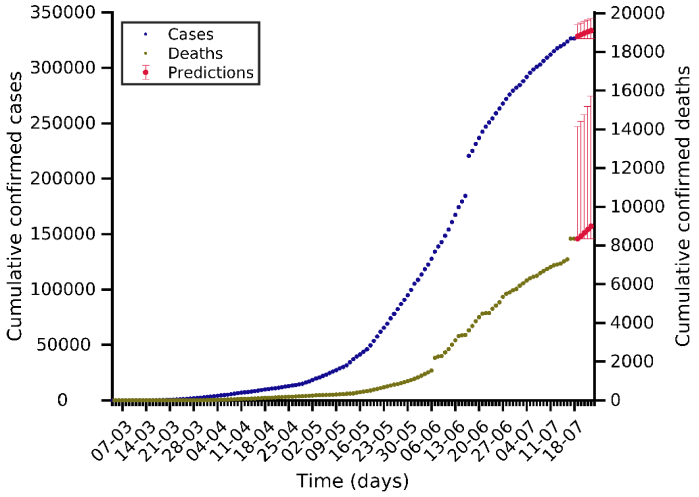


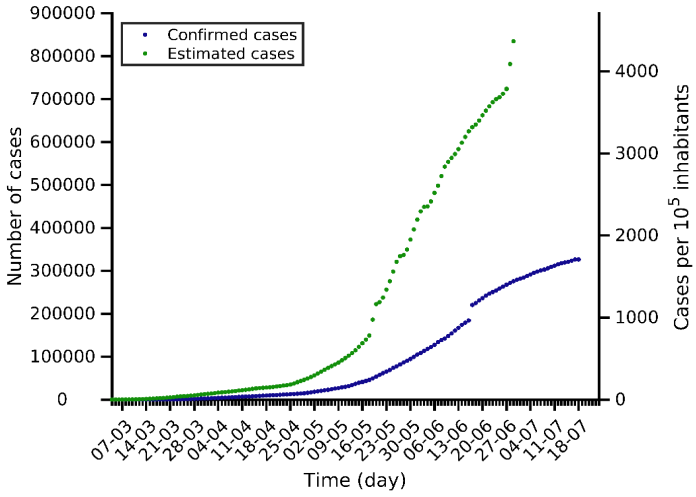


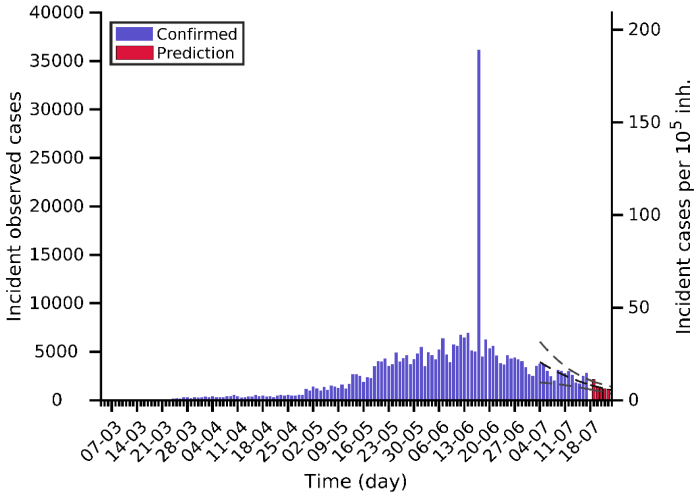


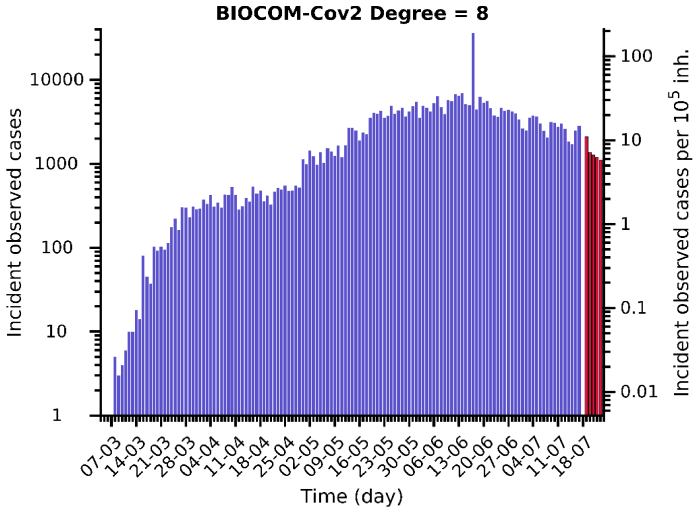


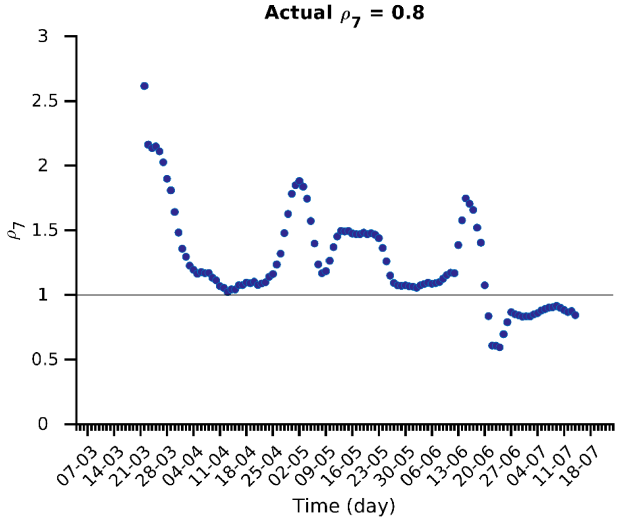
Chile 18-07-2020. Pop: 19.1M. Cumulative incidence: 1708/10^5

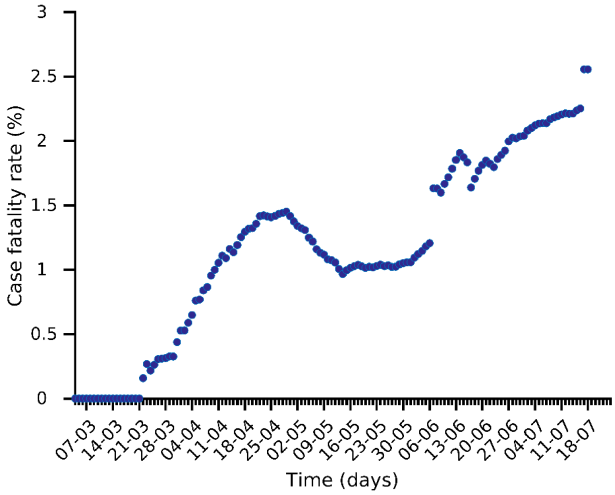


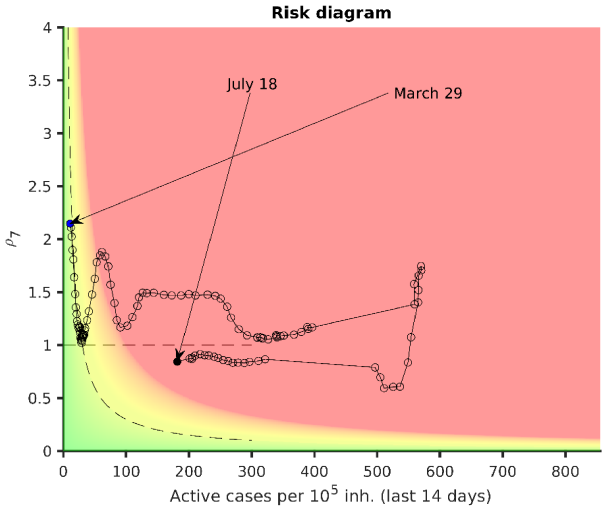


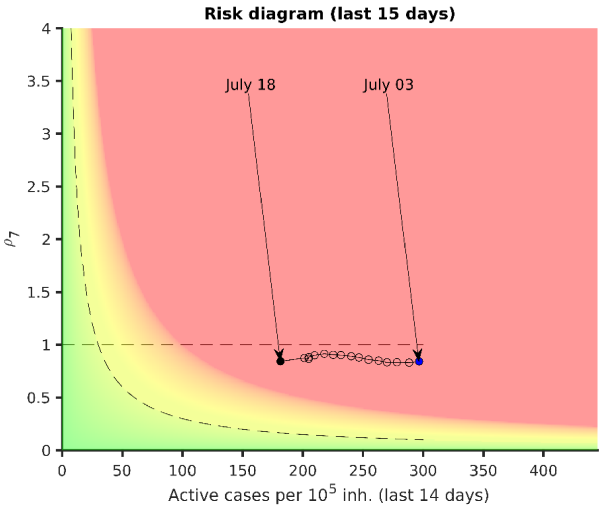




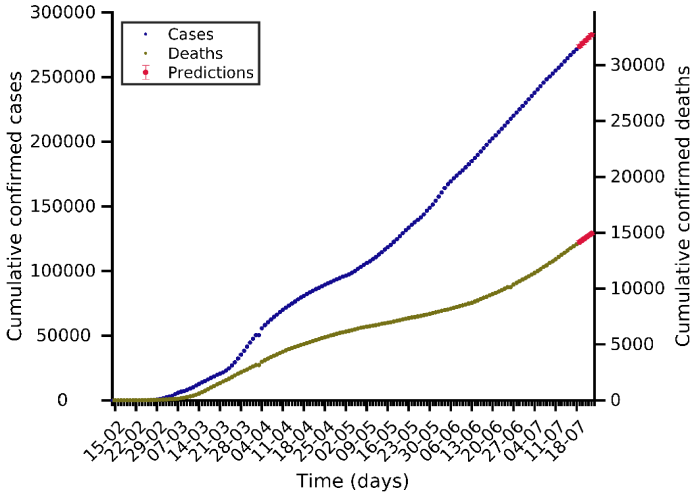


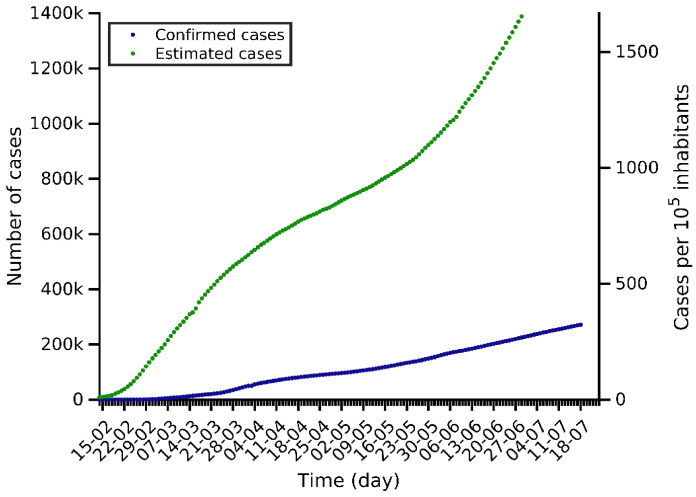


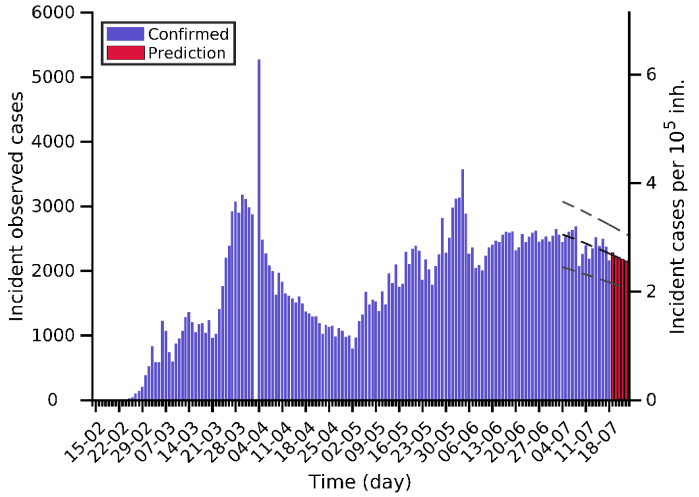


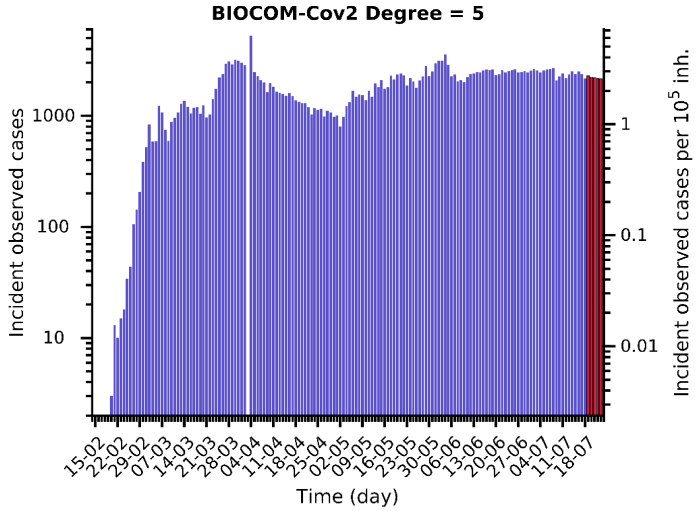


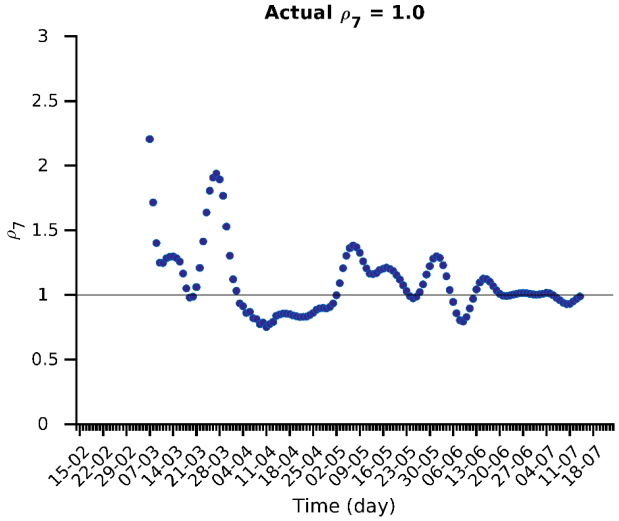
Iran 18-07-2020. Pop: 84.0M. Cumulative incidence: 323/10⁵

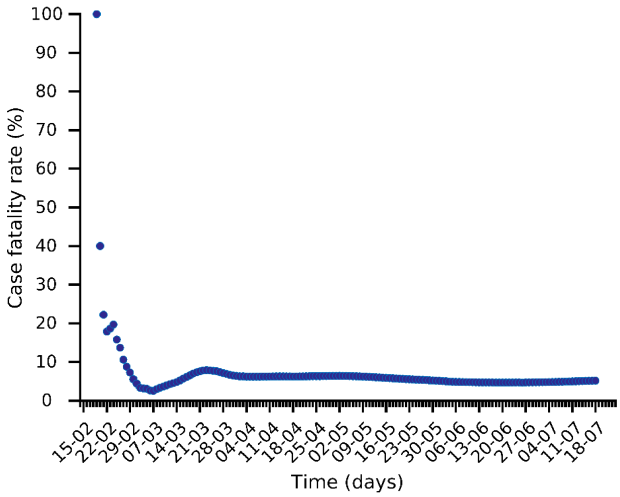


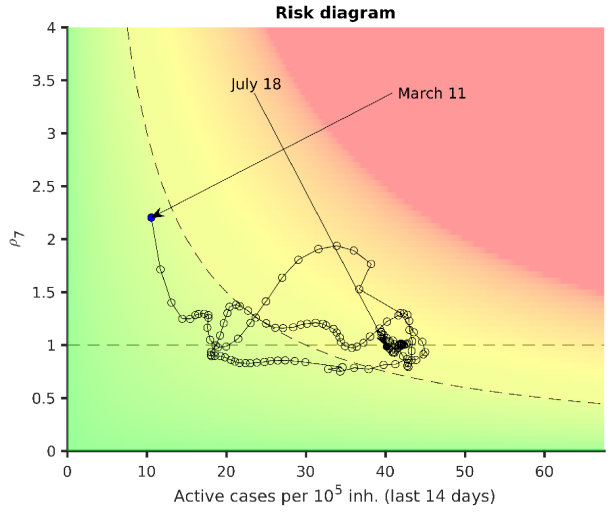


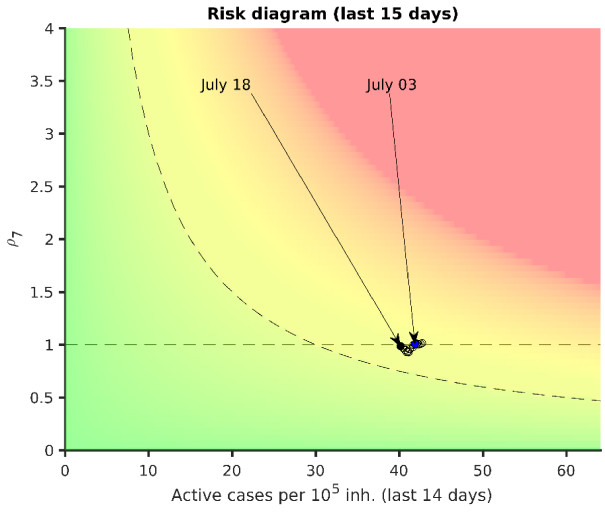




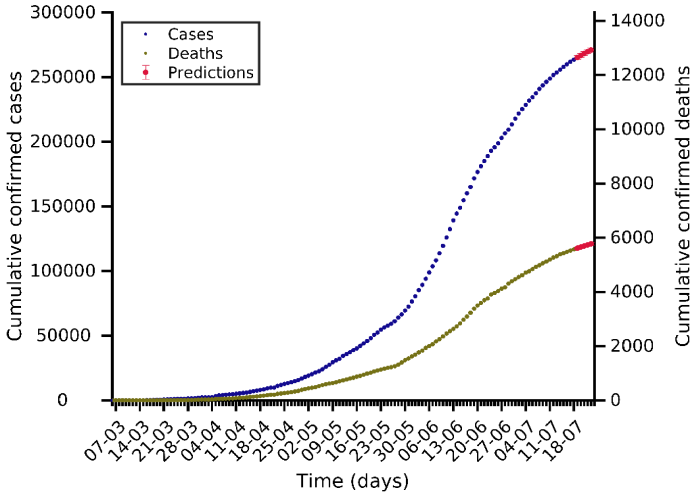


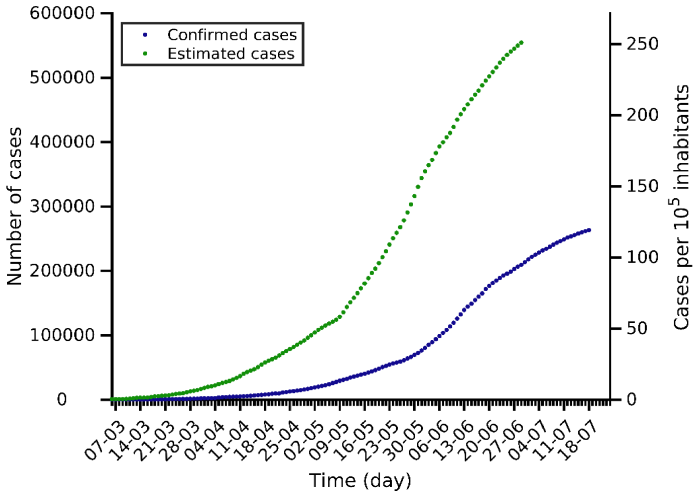


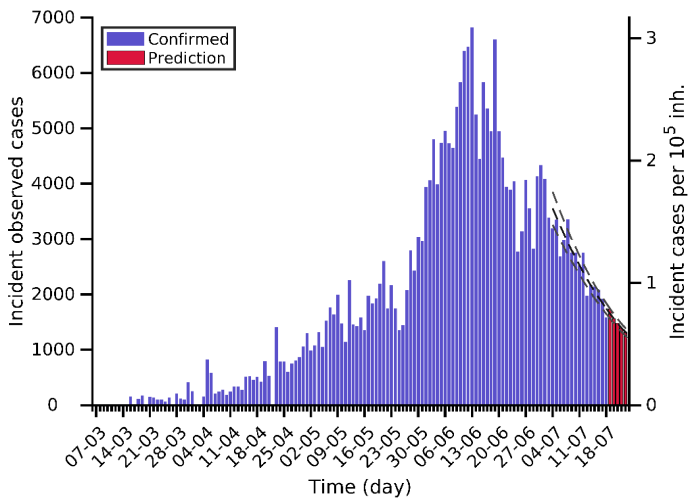


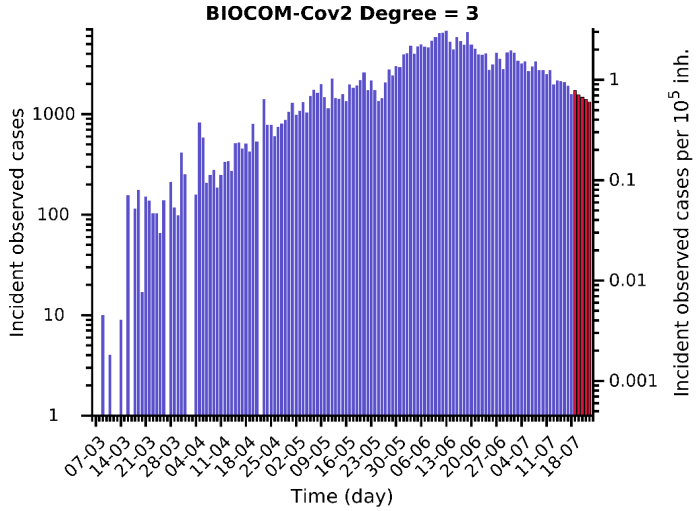


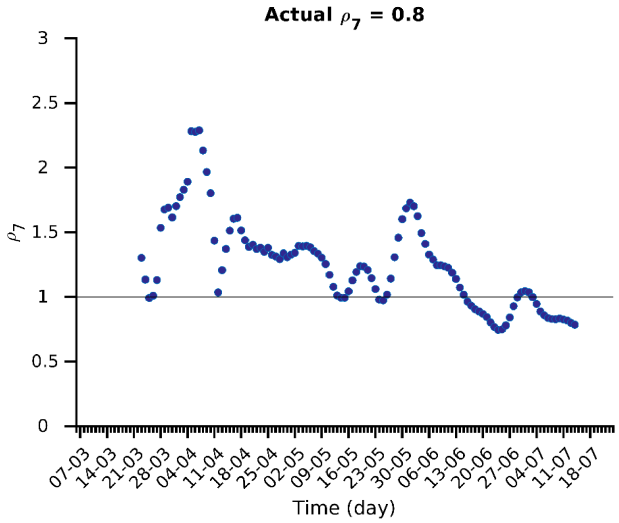
Pakistan 18-07-2020. Pop: 220.9M. Cumulative incidence: 119/10⁵

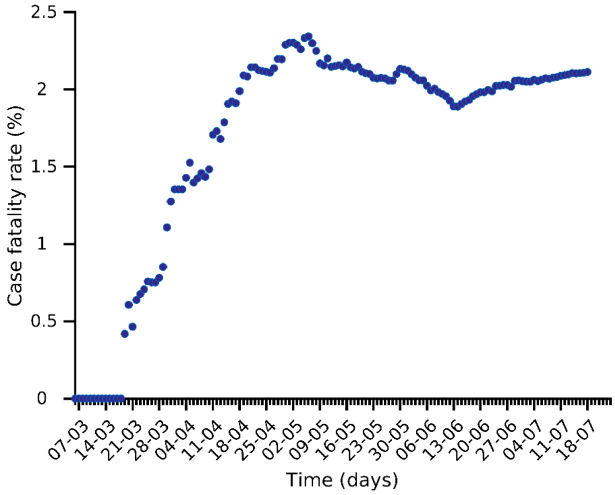


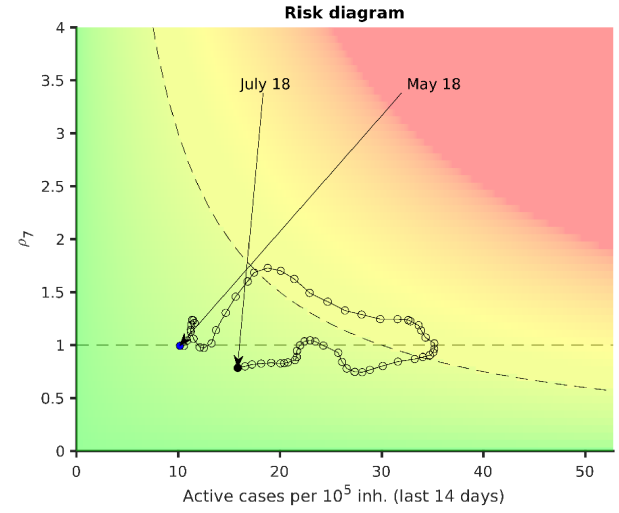


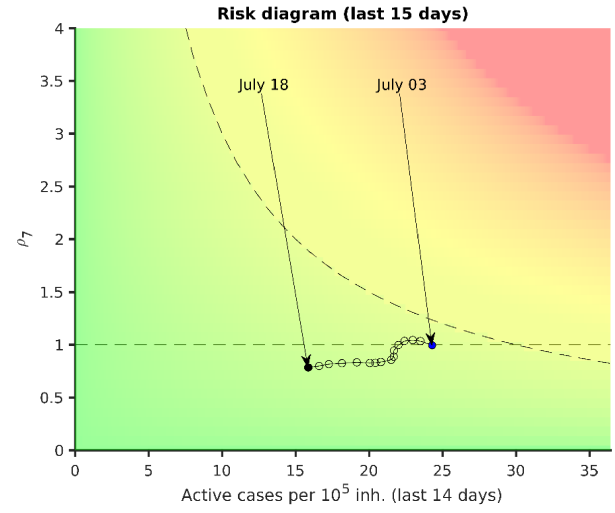




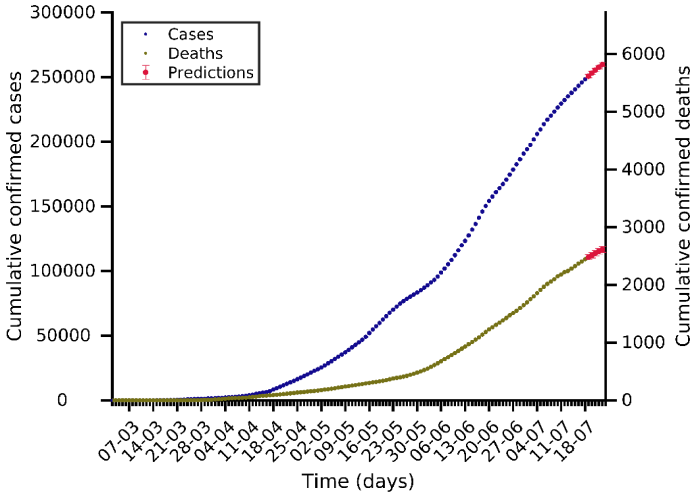


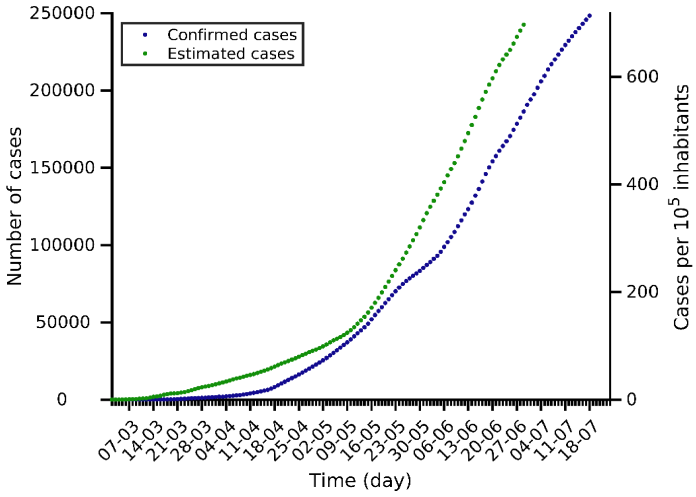


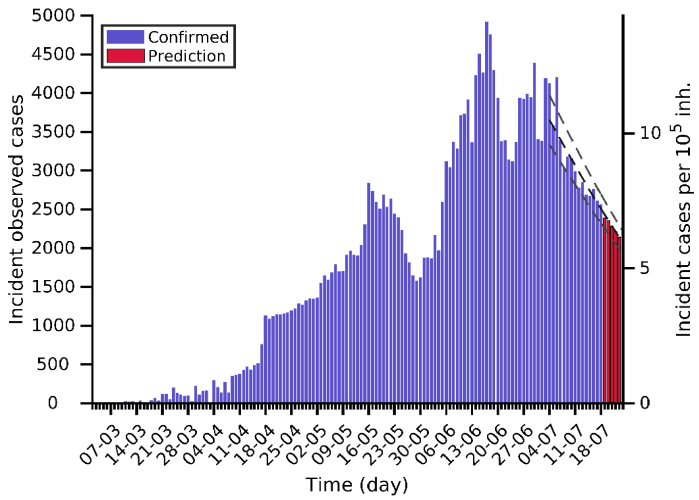


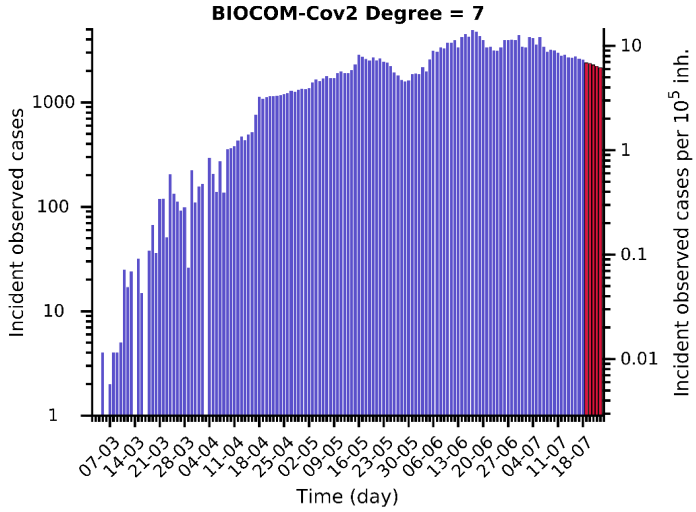


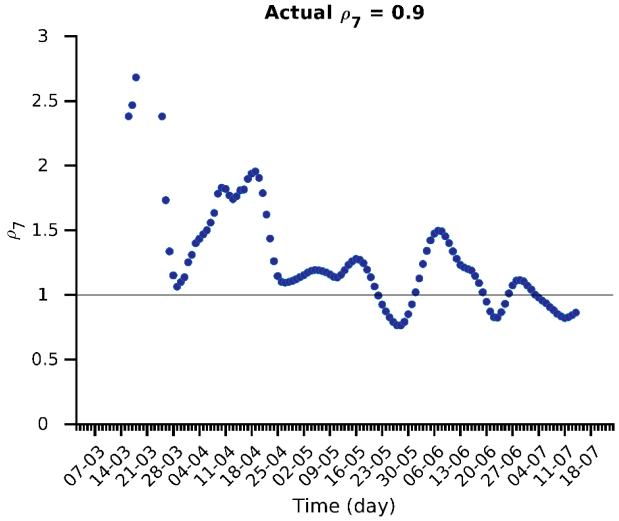
Saudi Arabia 18-07-2020. Pop: 34.8M. Cumulative incidence: 714/10⁵

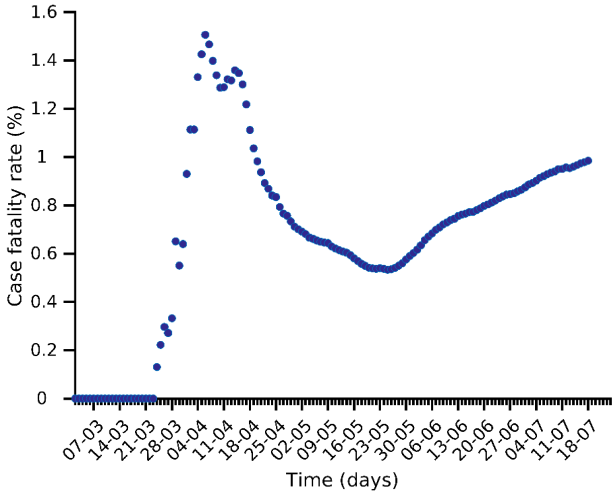


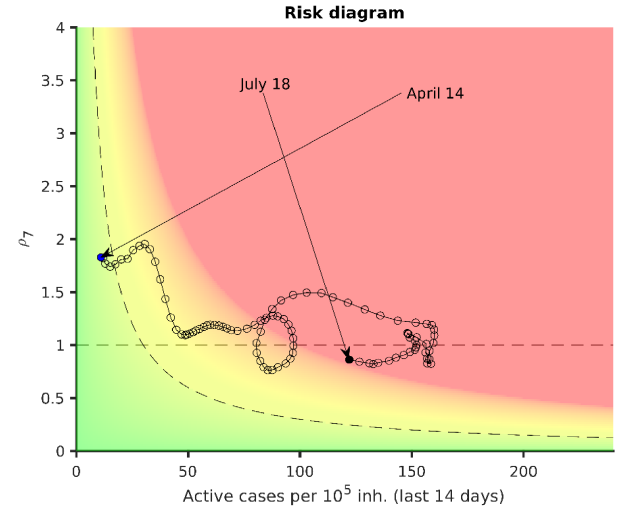


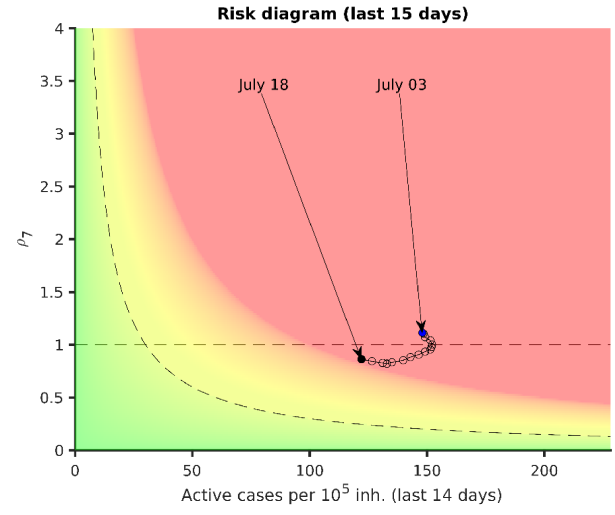




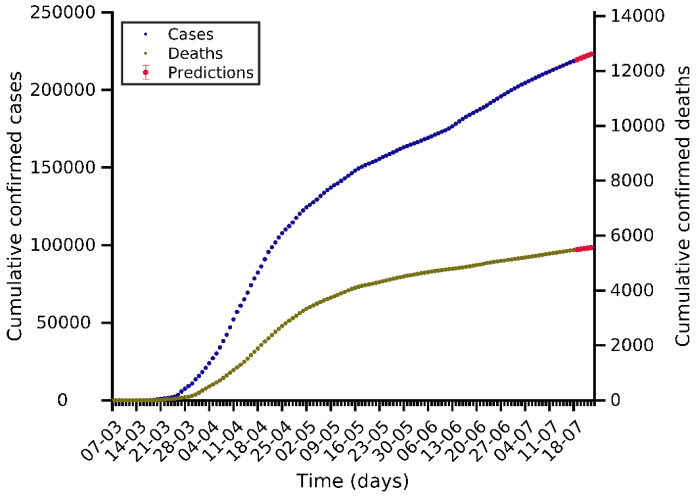


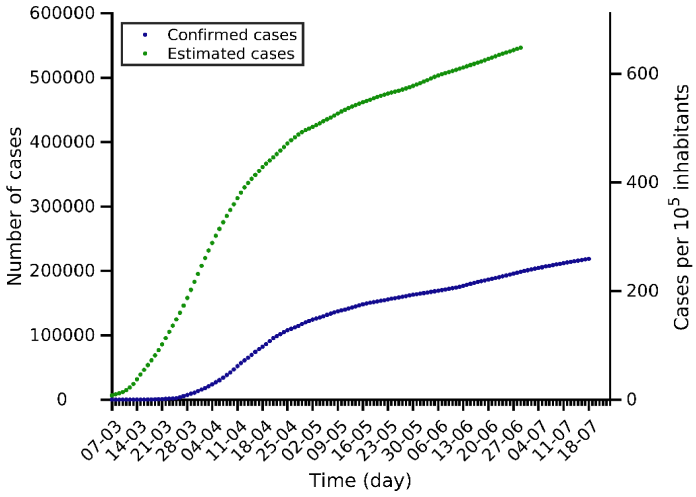


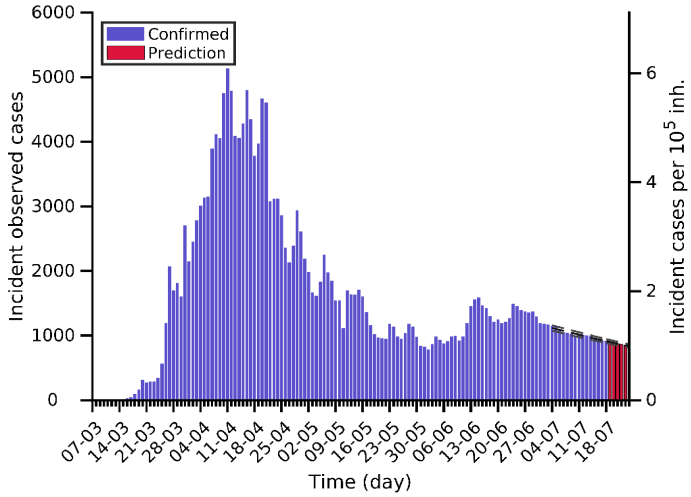


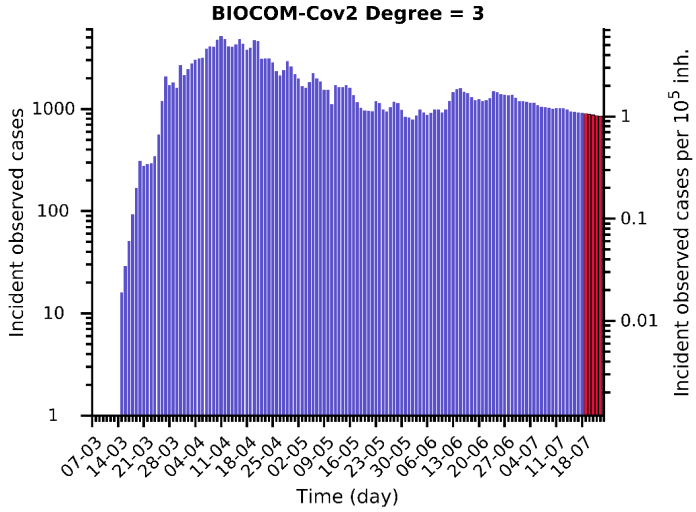


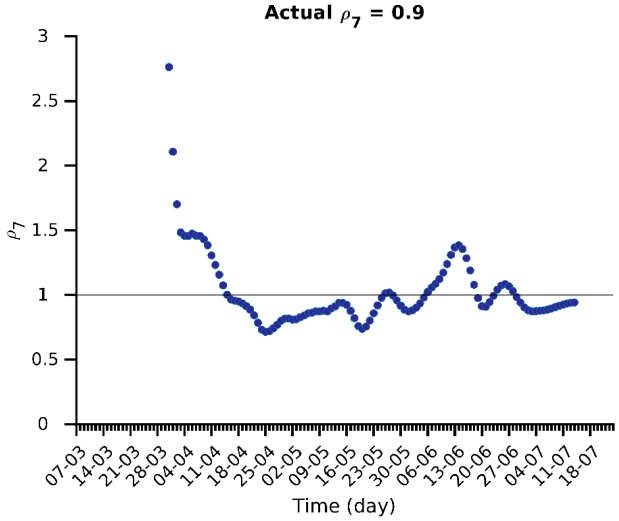
Turkey 18-07-2020. Pop: 84.3M. Cumulative incidence: 259/10⁵

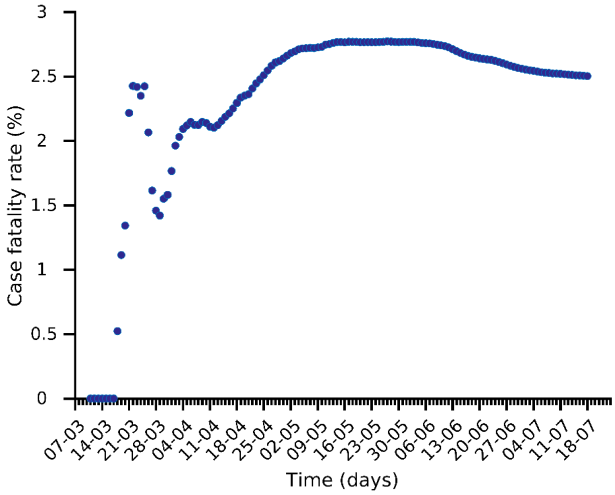


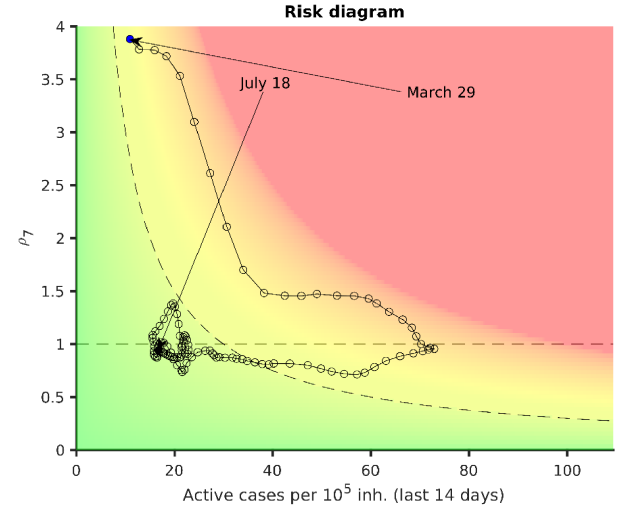


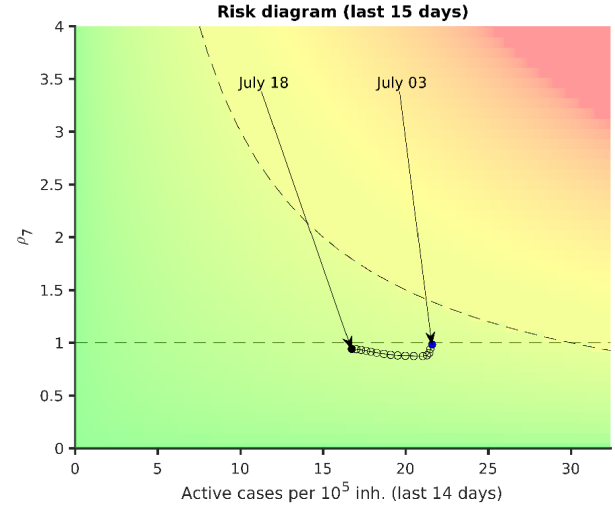




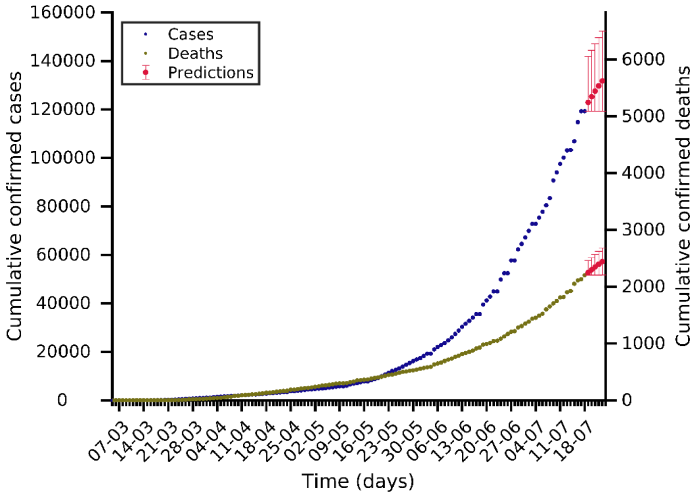


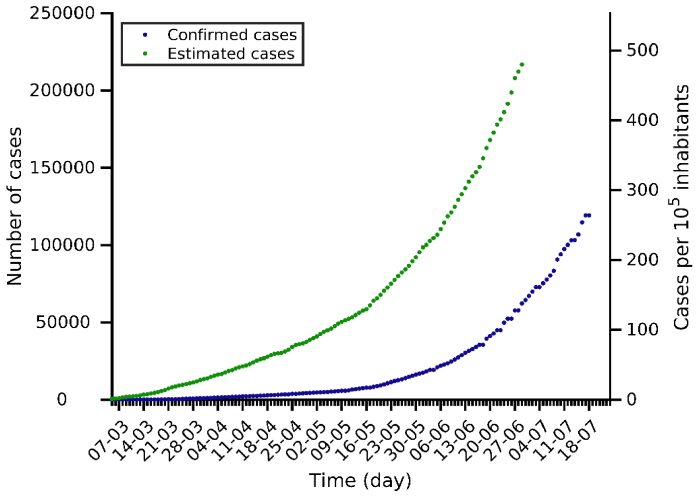


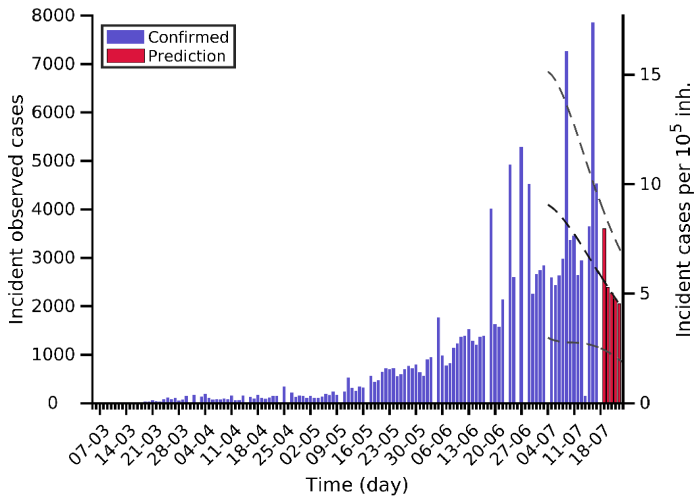


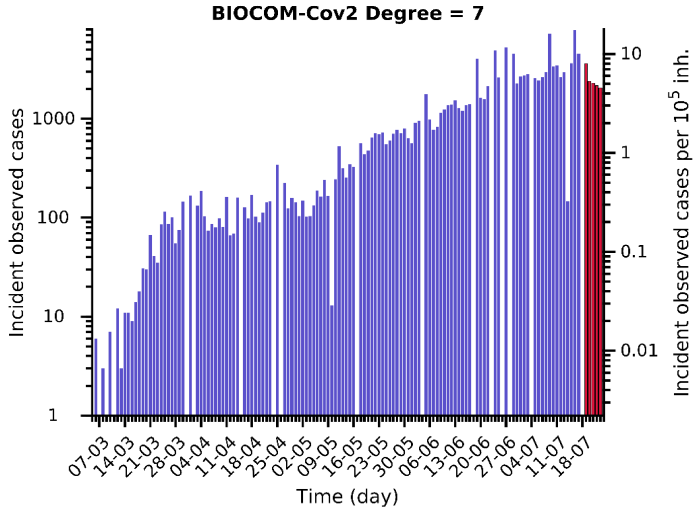


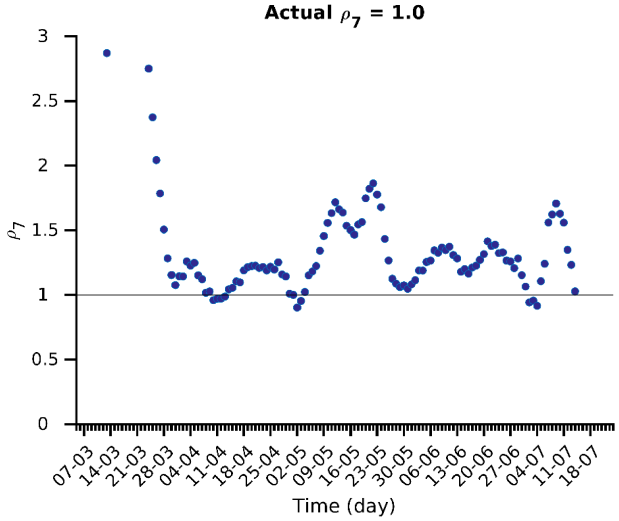
Argentina 18-07-2020. Pop: 45.2M. Cumulative incidence: 264/10⁵

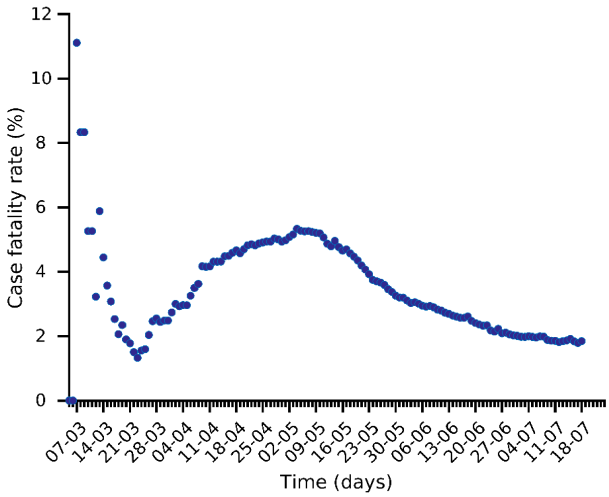


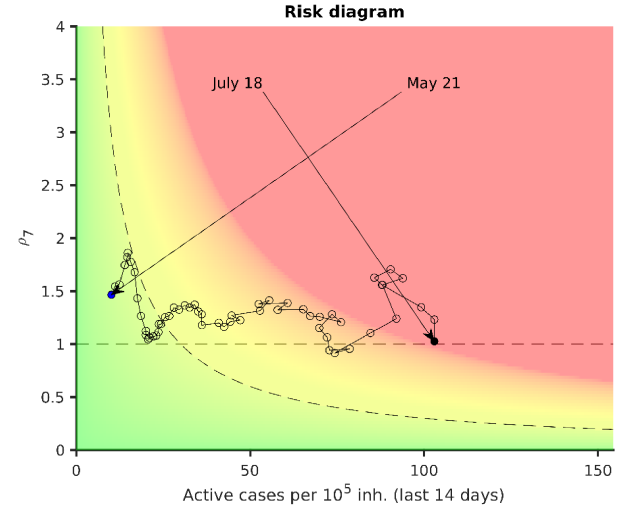


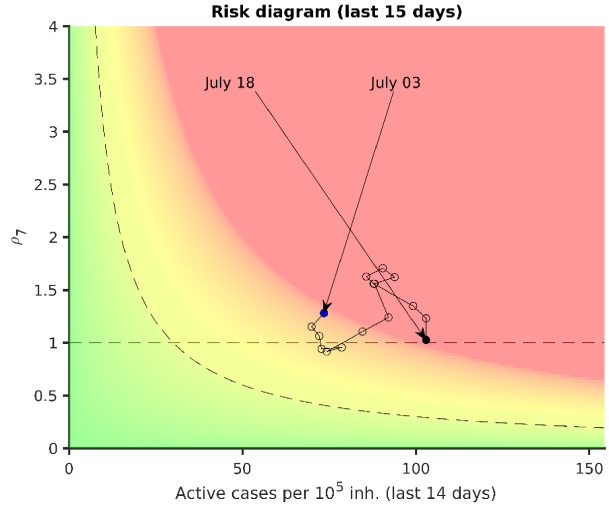




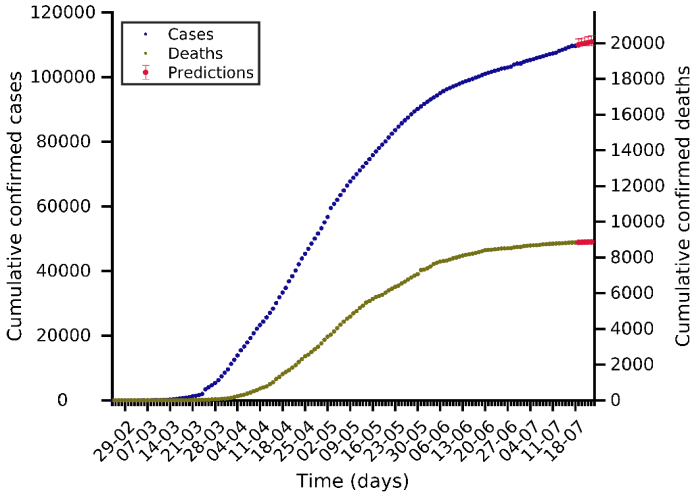


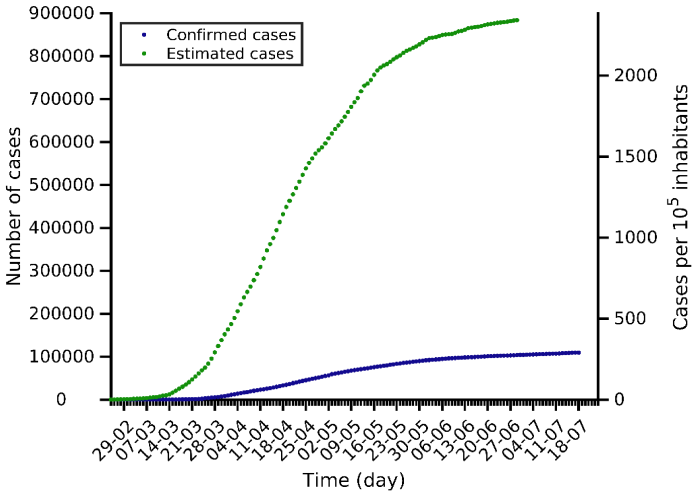


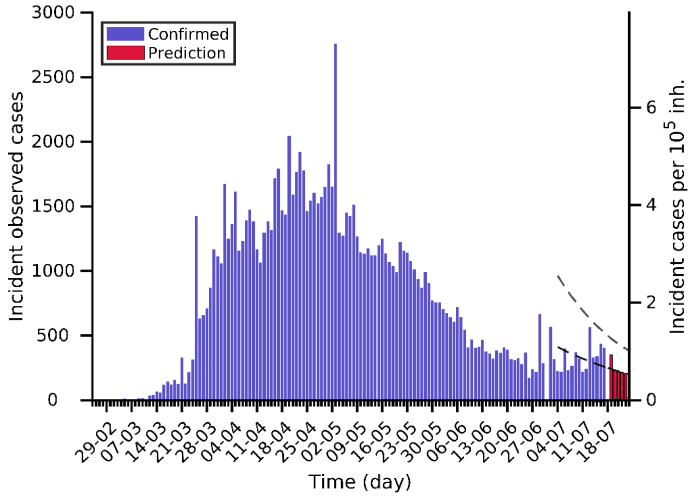


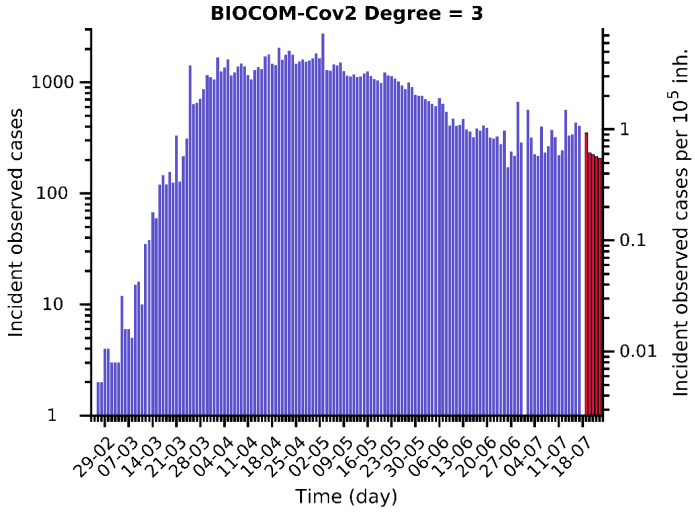


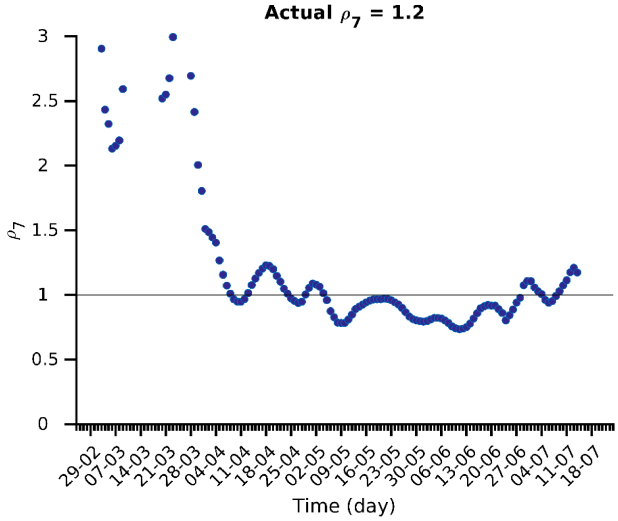
Canada 18-07-2020. Pop: 37.7M. Cumulative incidence: 291/10⁵

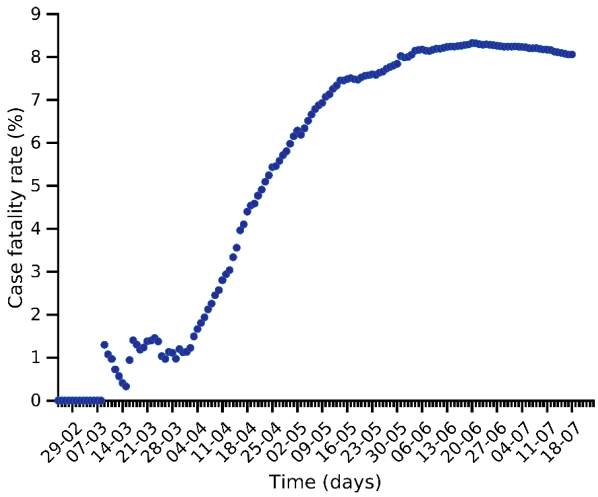


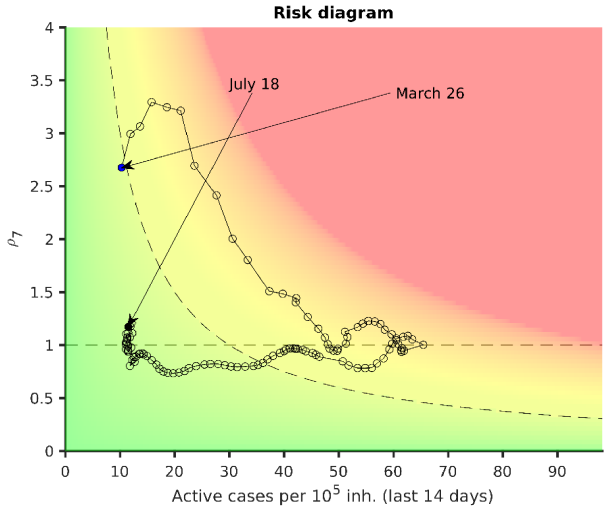


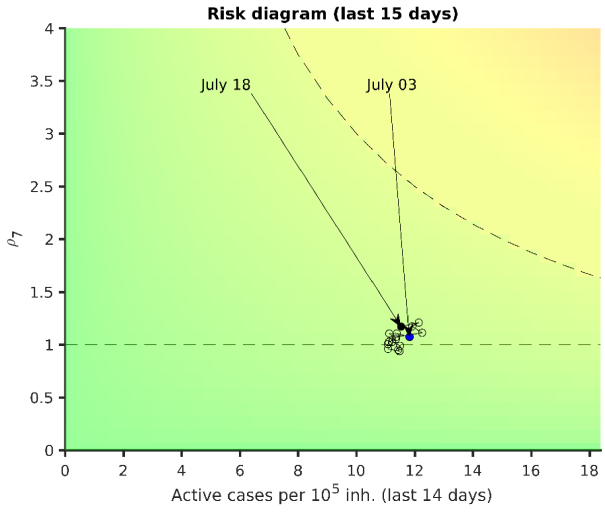




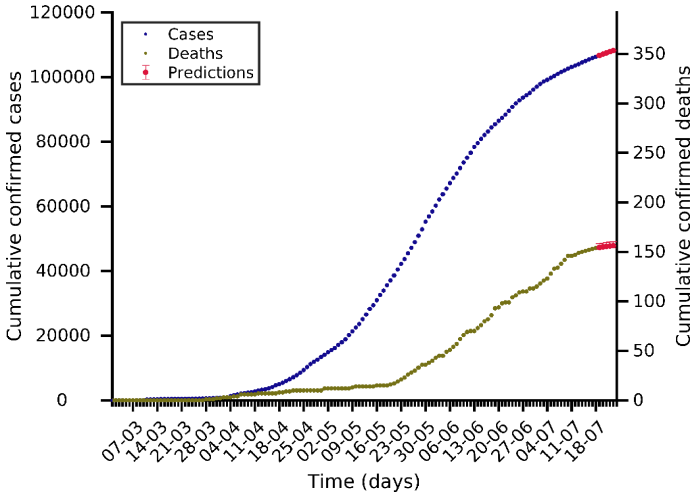


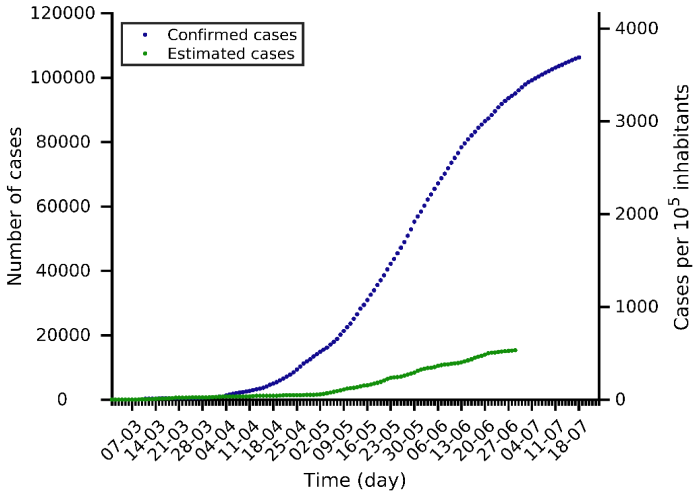


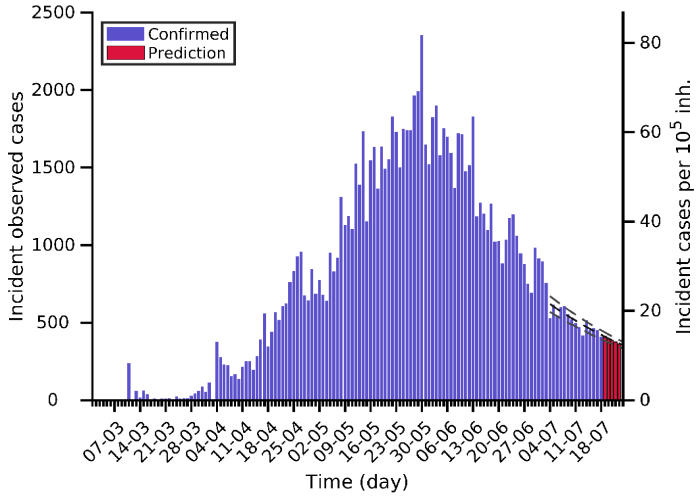


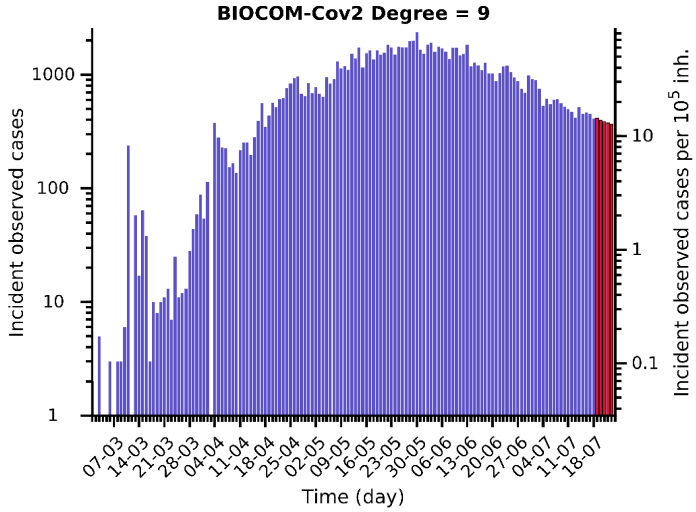


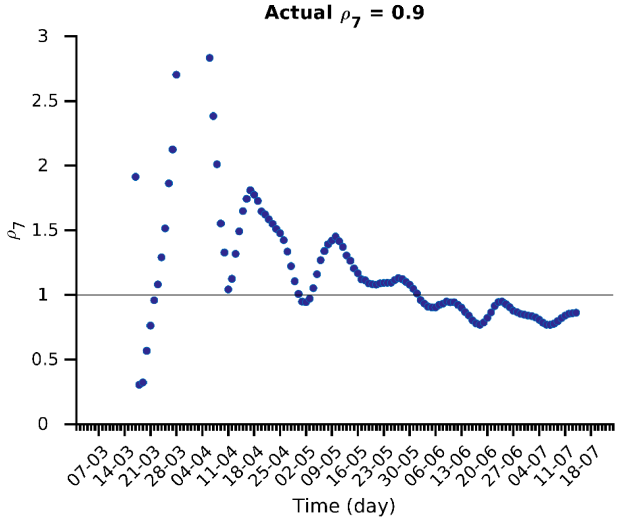
Qatar 18-07-2020. Pop: 2.9M. Cumulative incidence: 3690/10⁵

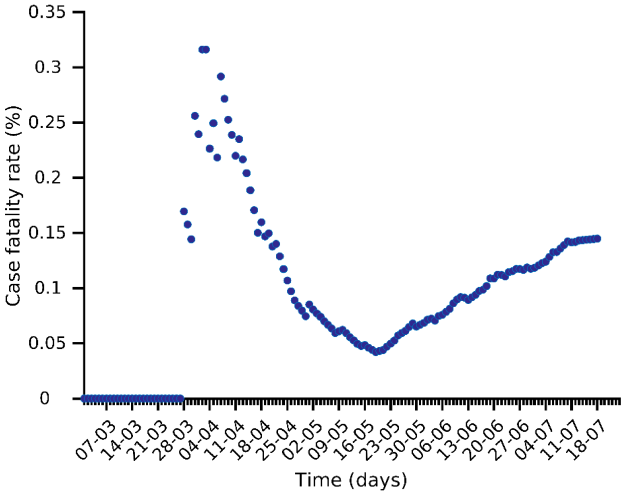


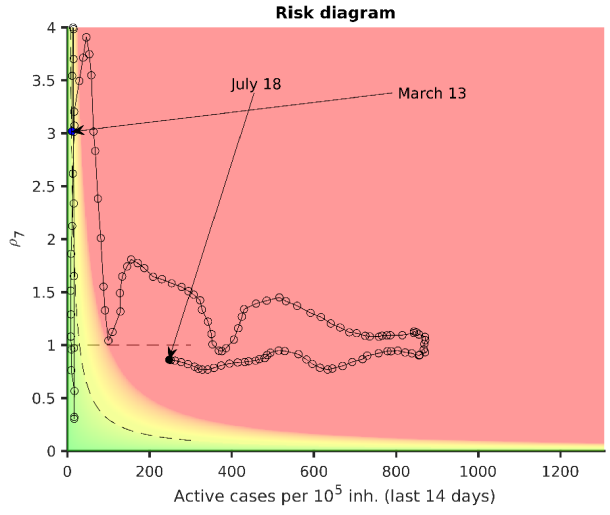


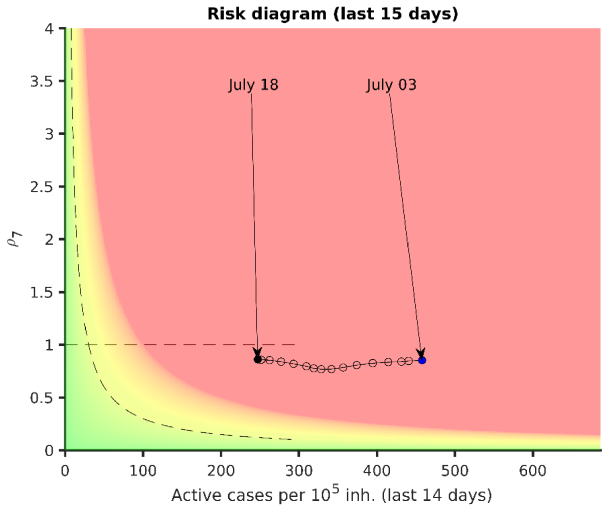




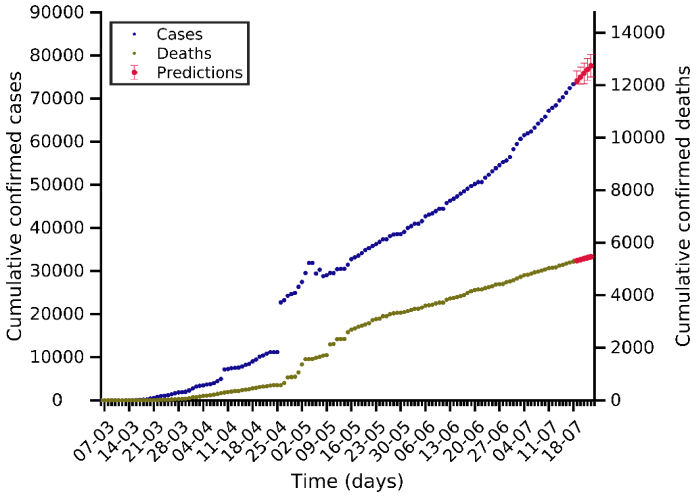


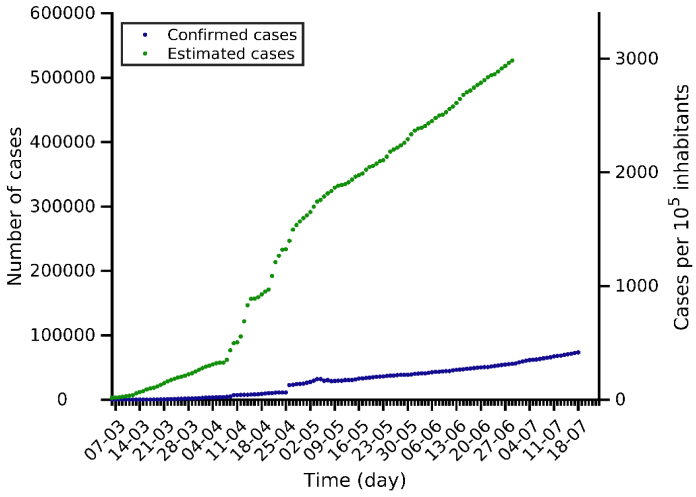


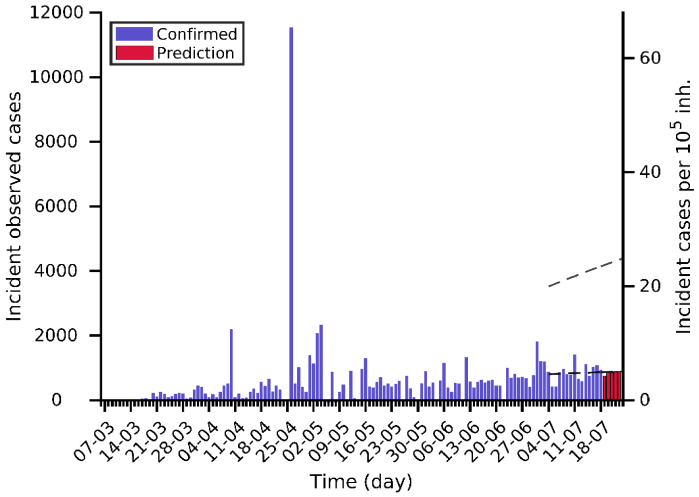


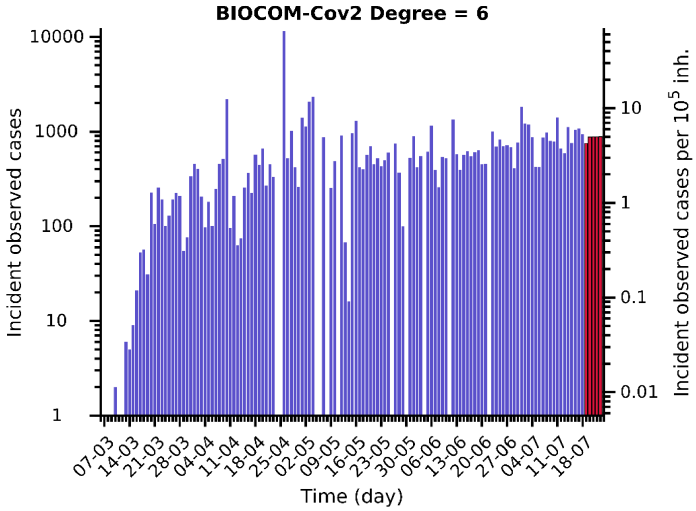


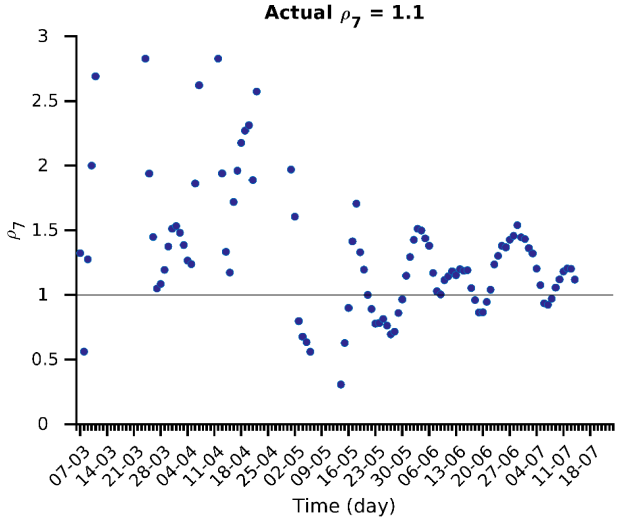
Ecuador 18-07-2020. Pop: 17.6M. Cumulative incidence: 416/10^5

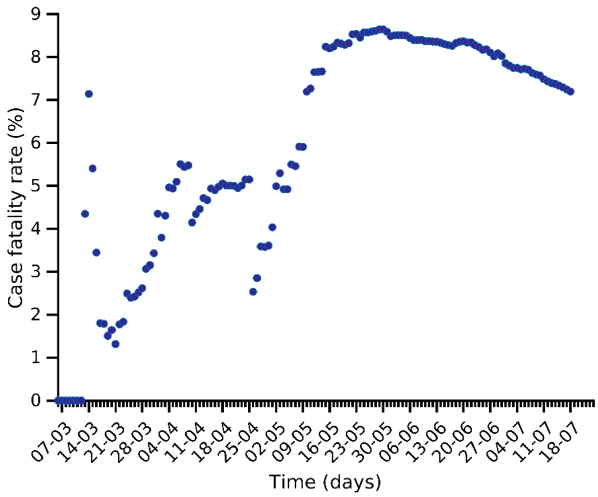


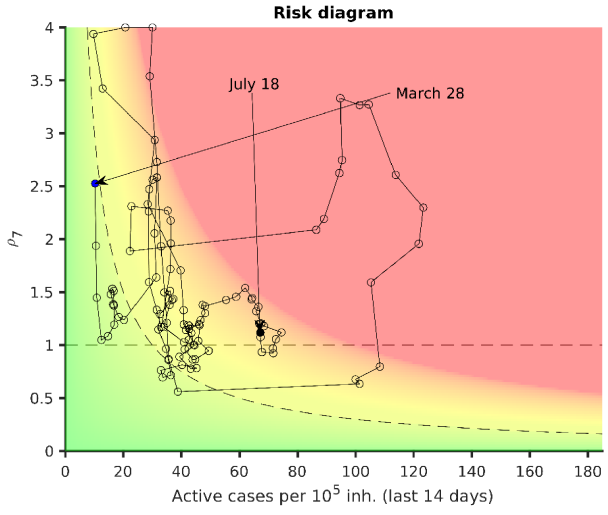


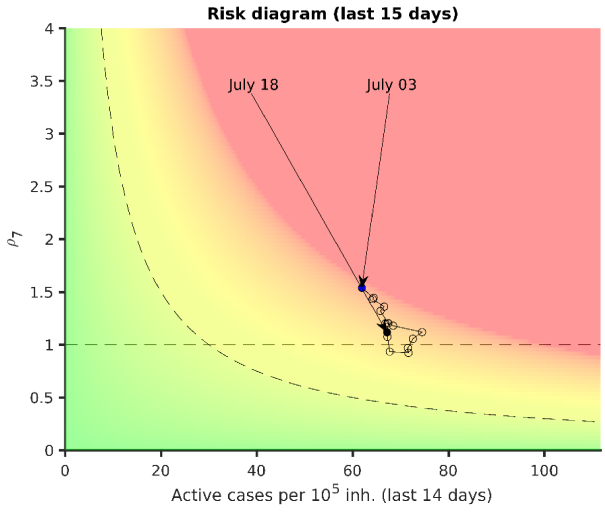




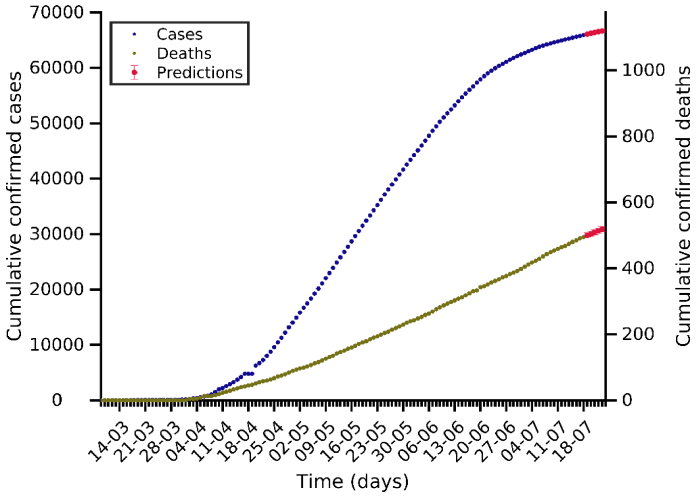


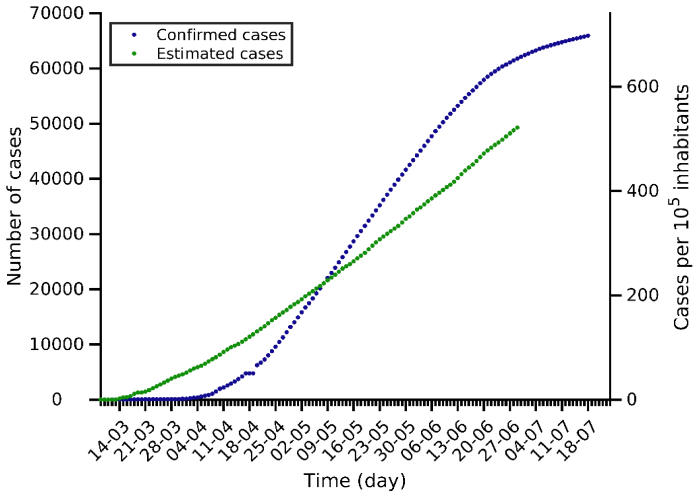


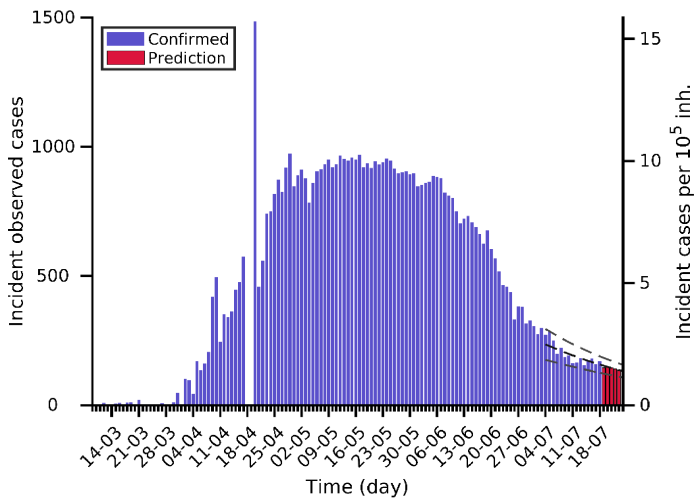


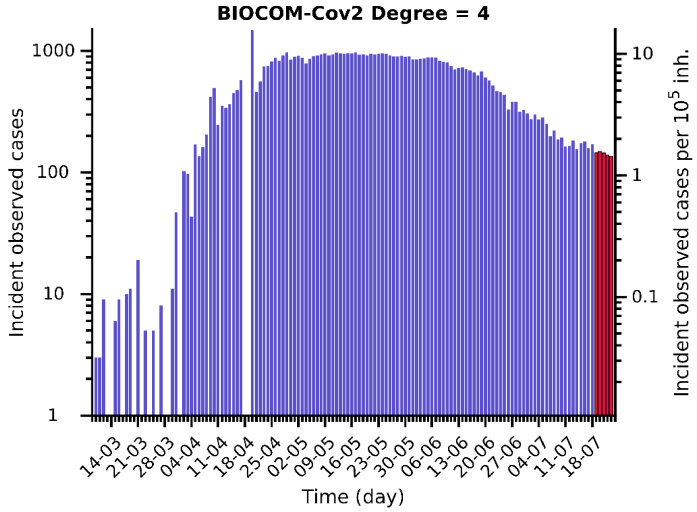


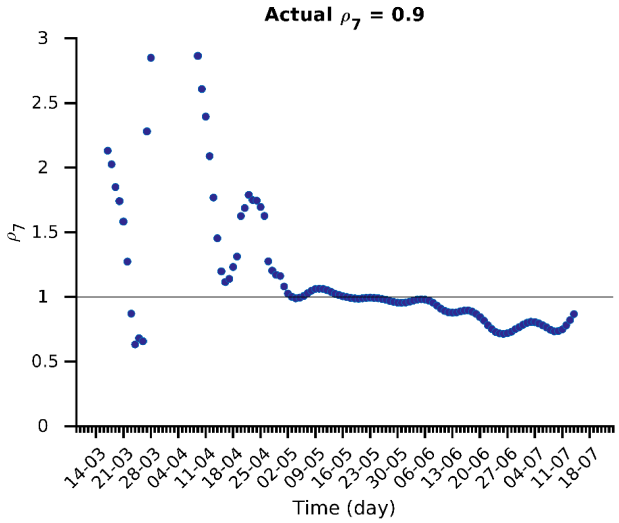
Belarus 18-07-2020. Pop: 9.4M. Cumulative incidence: 698/10^5

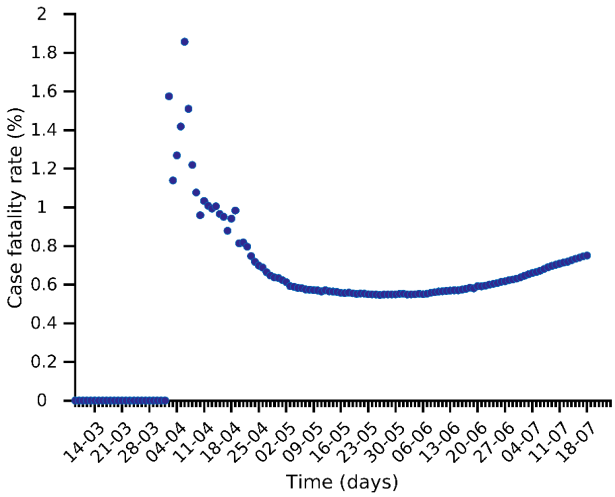


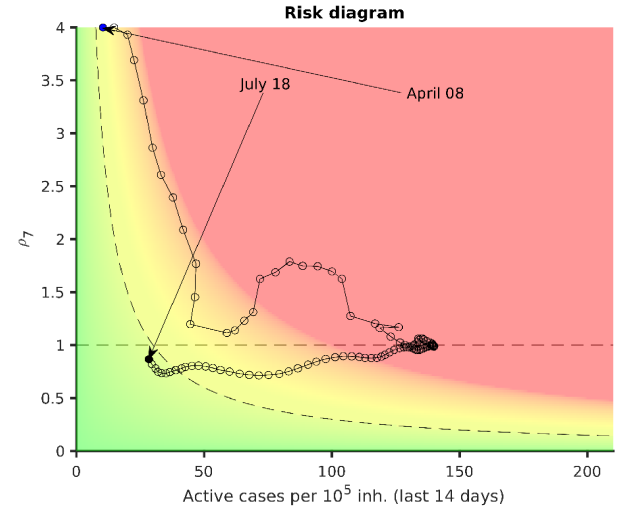


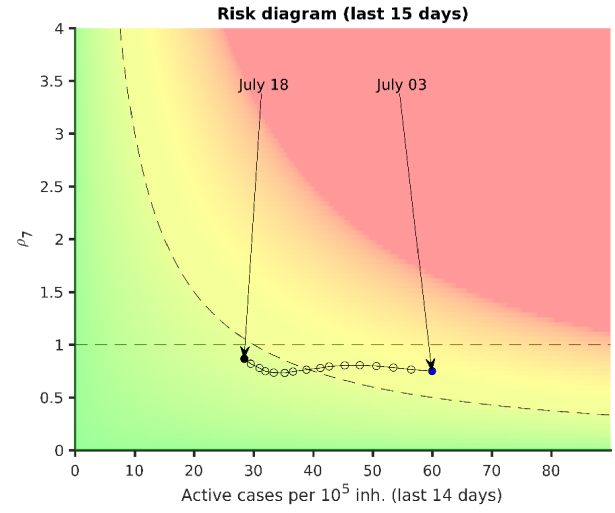




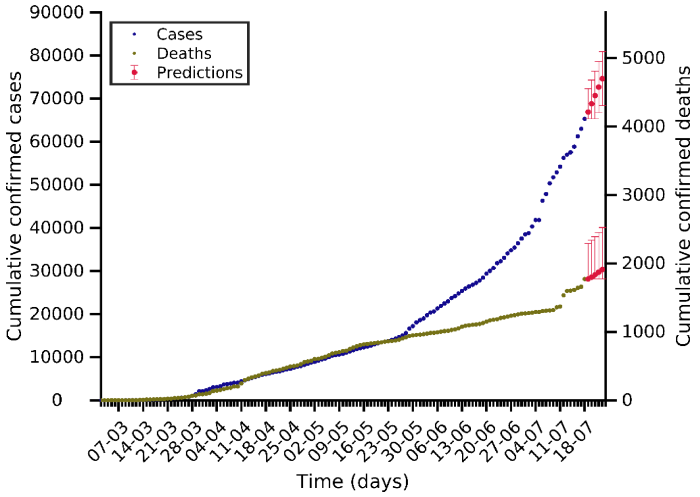


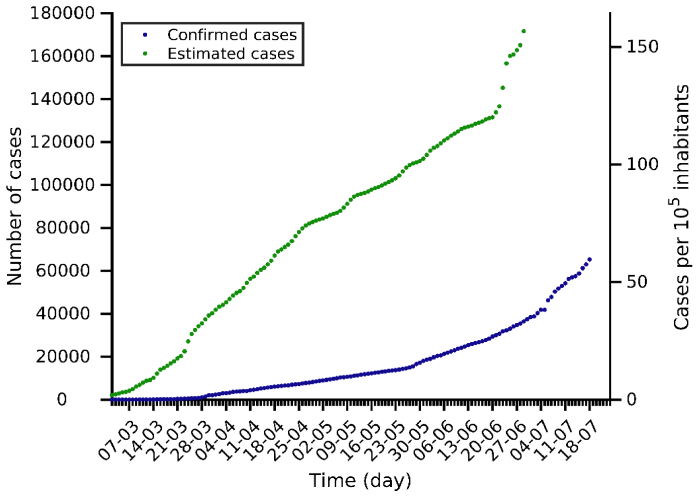


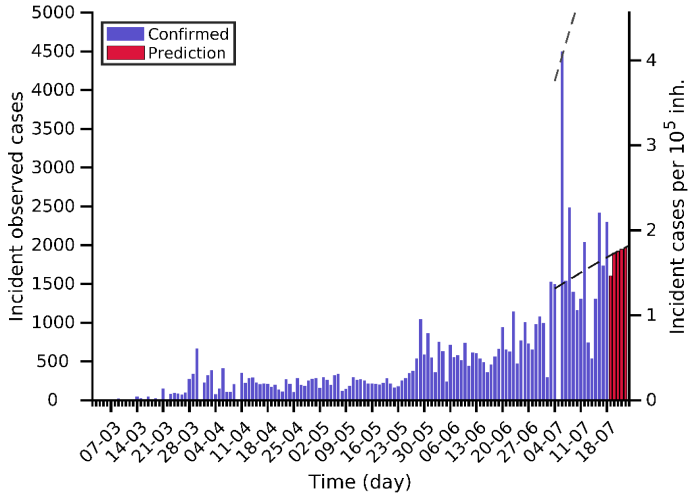


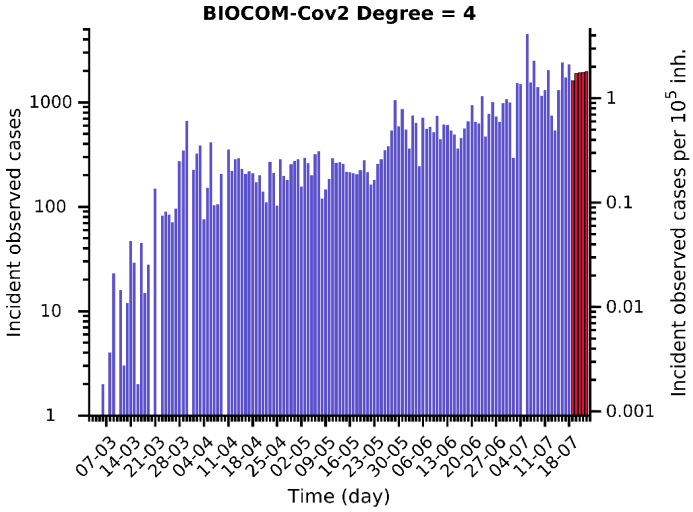


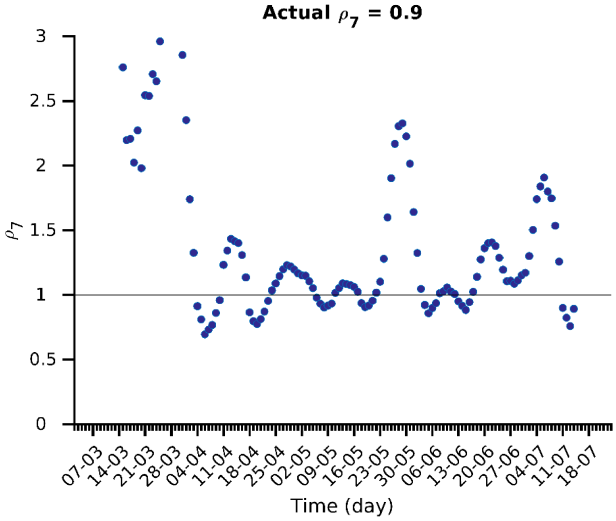
Philippines 18-07-2020. Pop: 109.6M. Cumulative incidence: 60/10^5

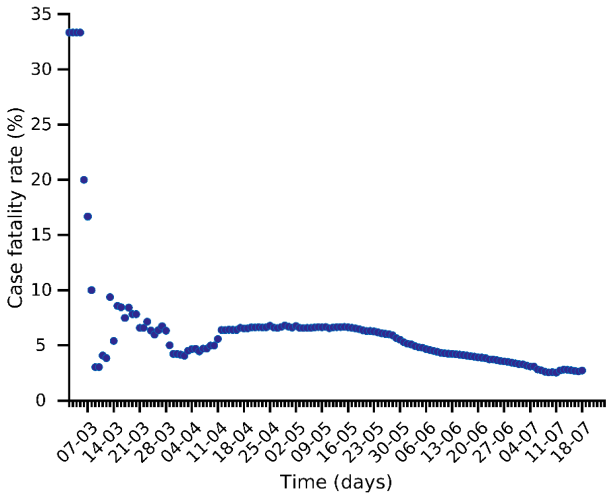


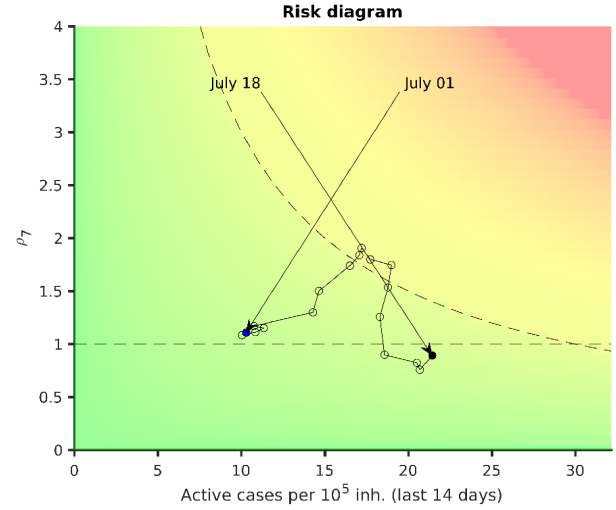


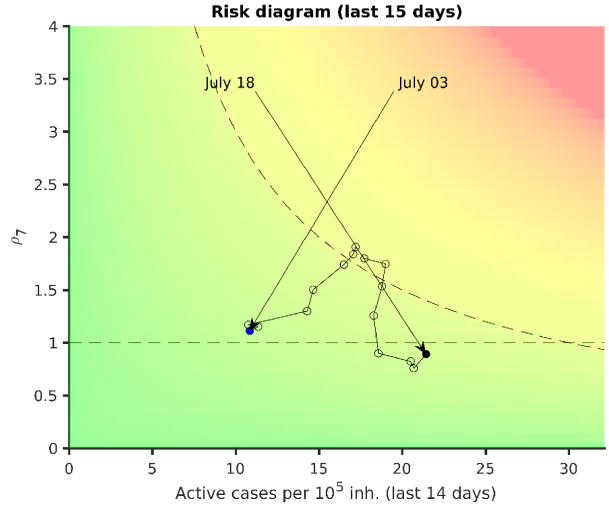




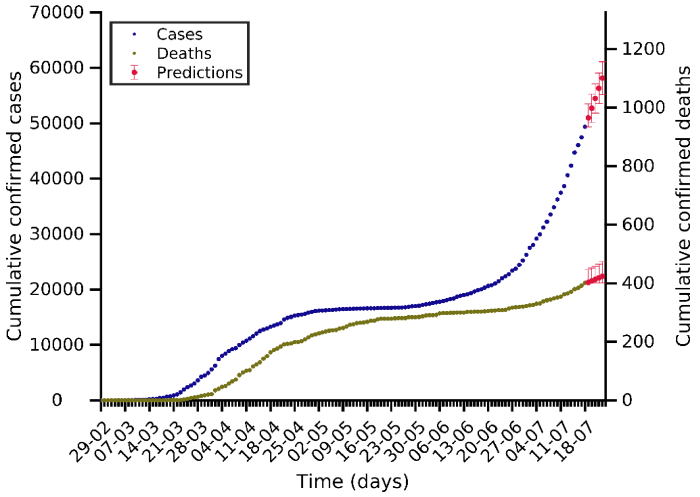


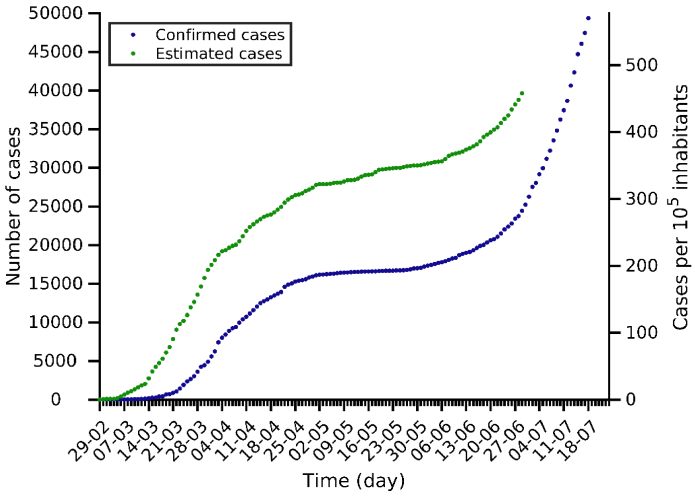


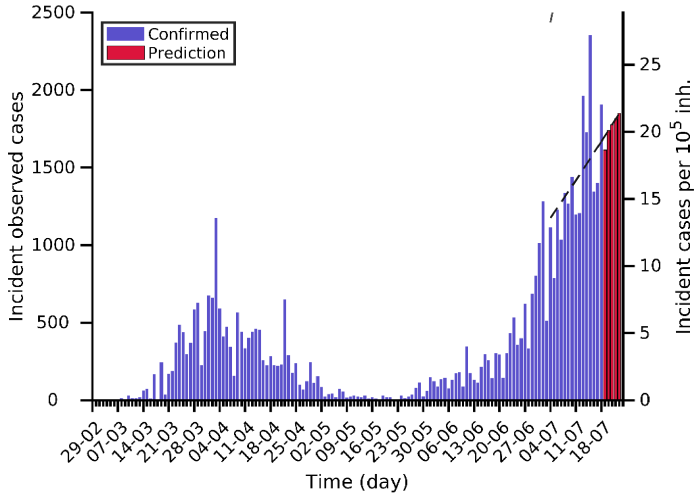


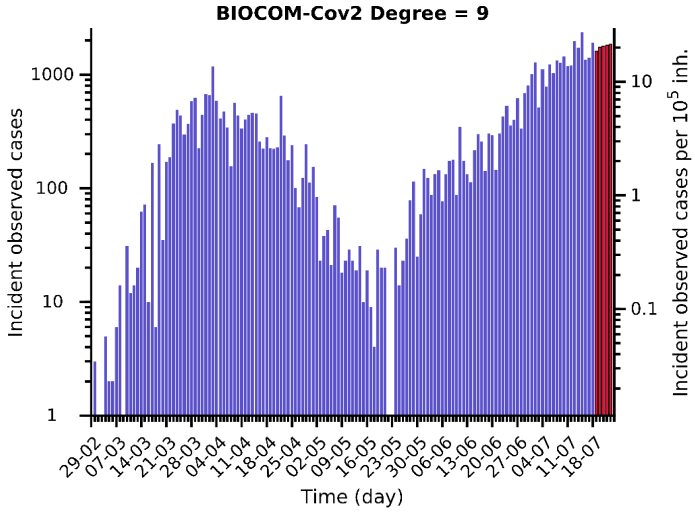


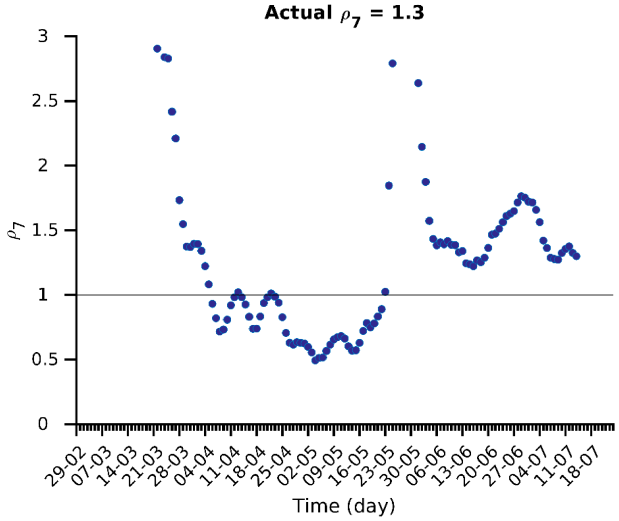
Israel 18-07-2020. Pop: 8.7M. Cumulative incidence: 570/10⁵

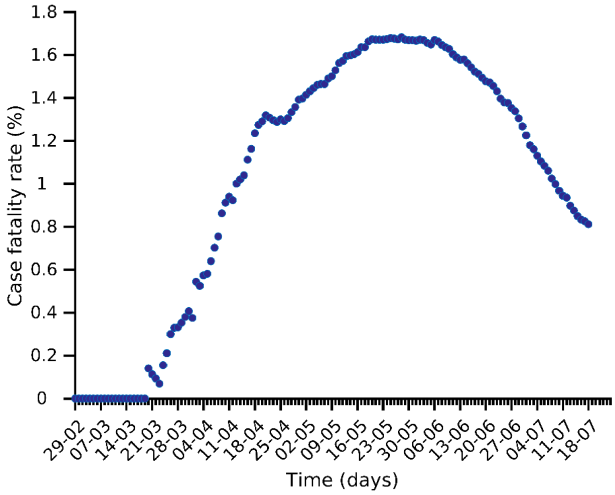


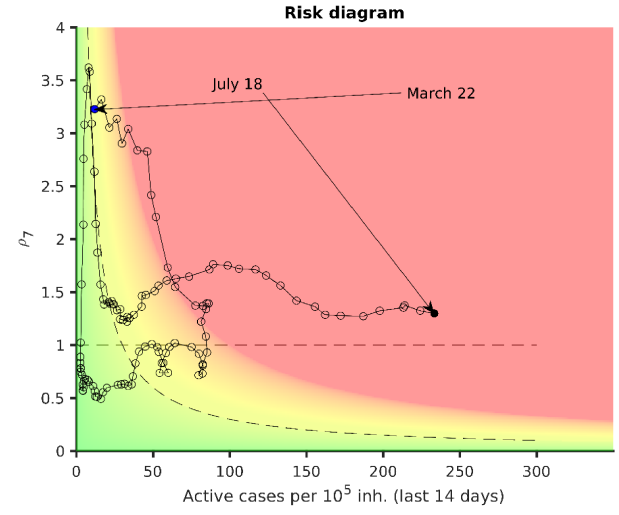


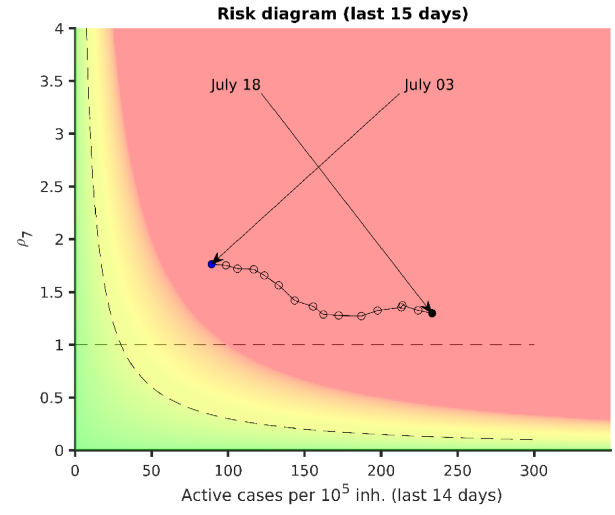




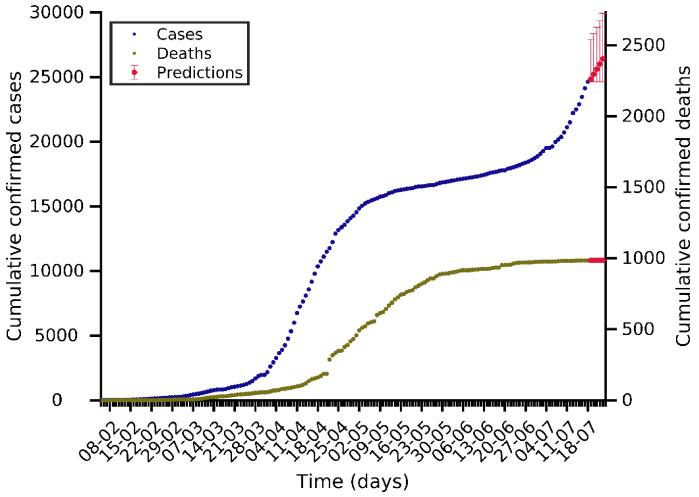


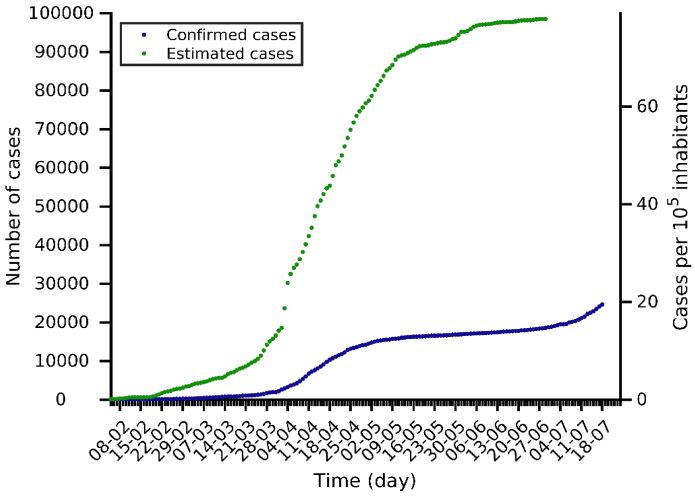


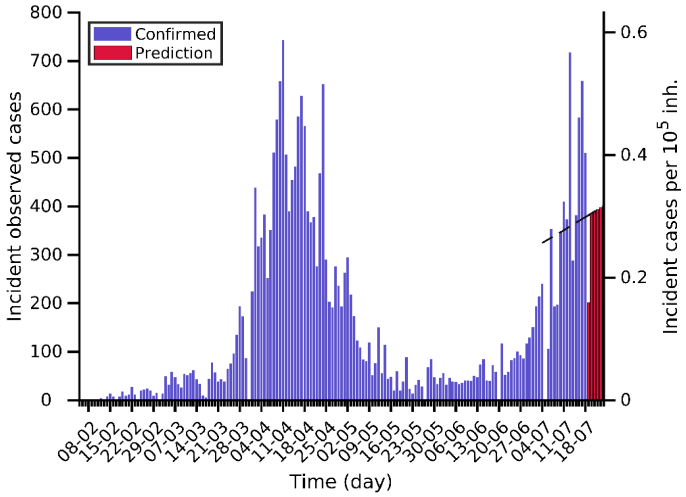


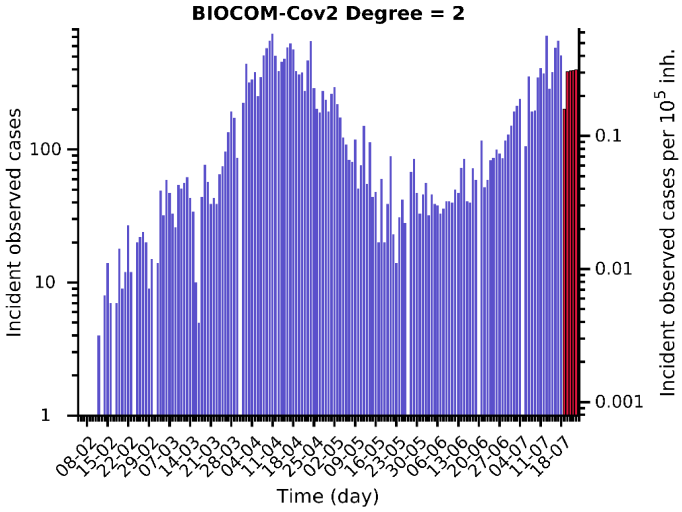


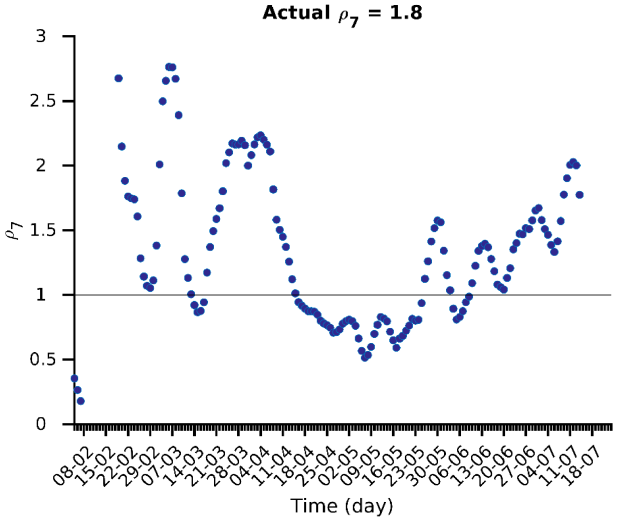
Japan 18-07-2020. Pop: 126.5M. Cumulative incidence: 19/10^5

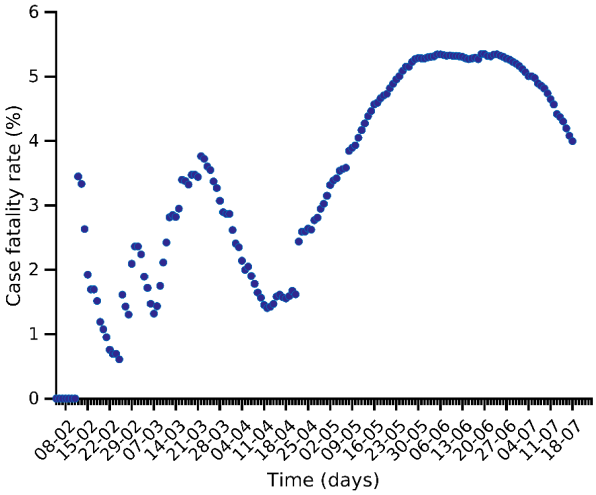


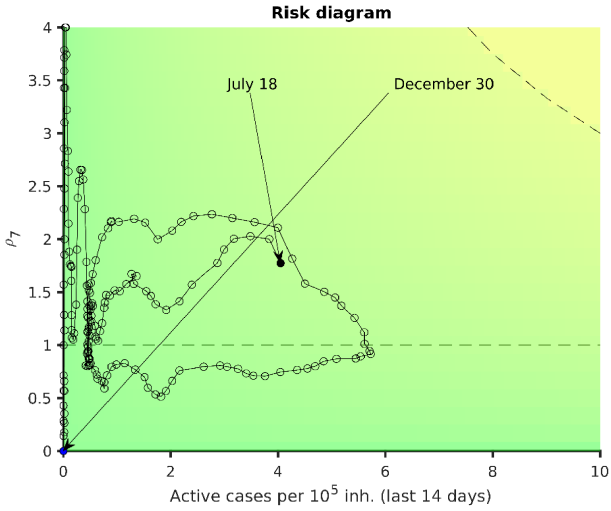


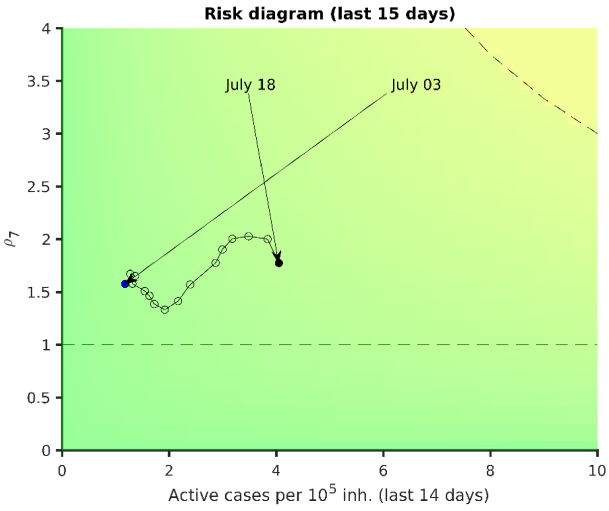




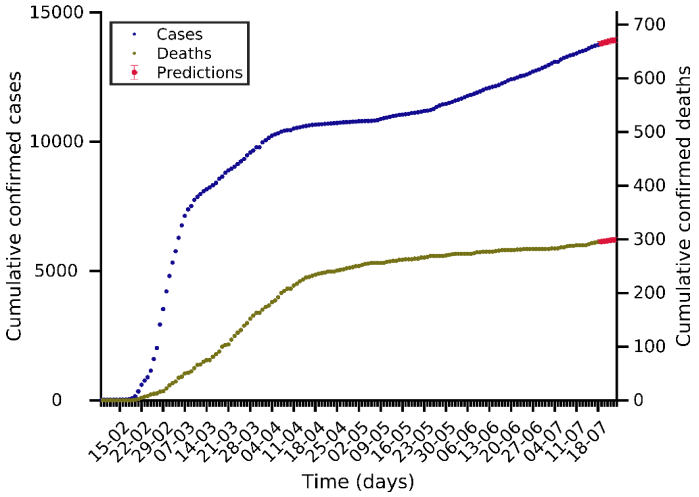


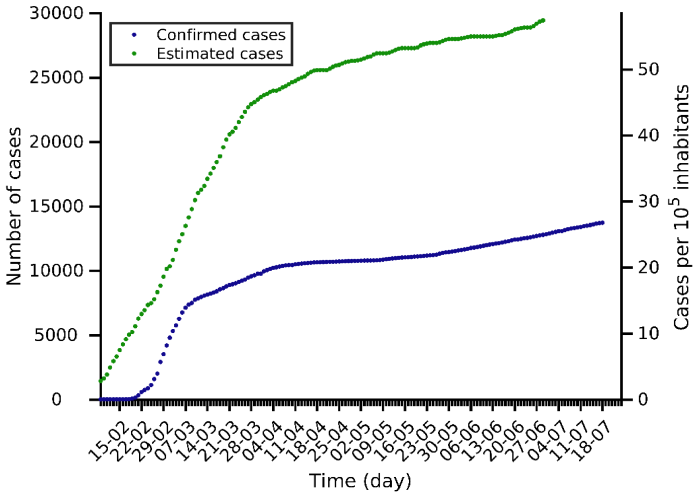


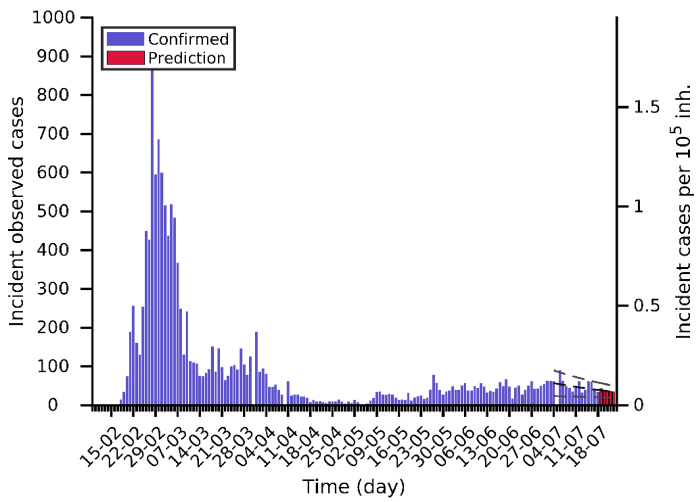


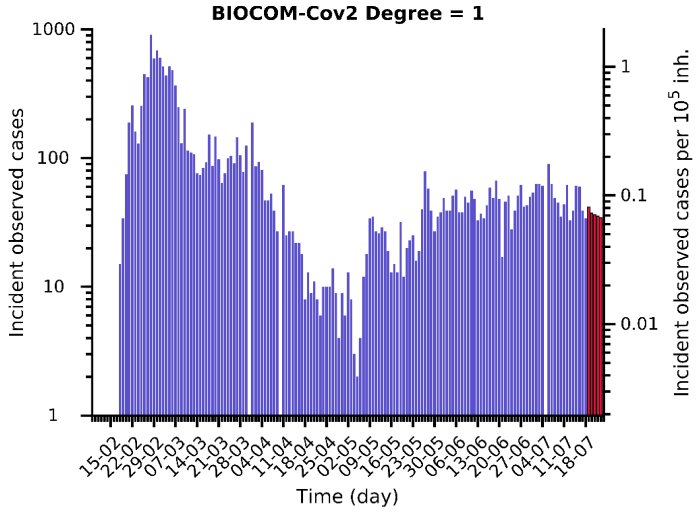


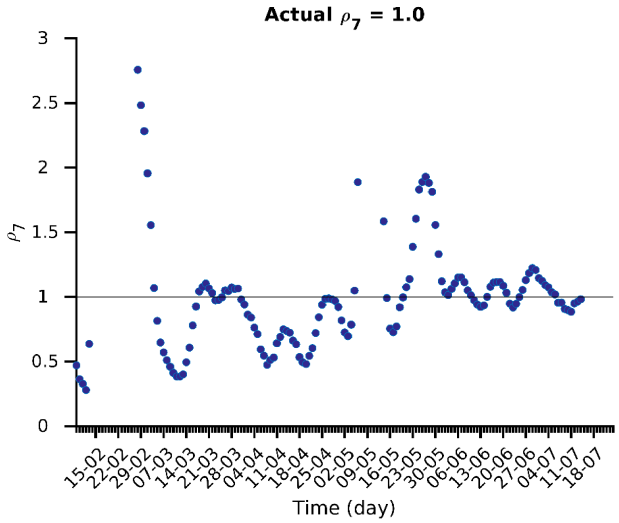
South Korea 18-07-2020. Pop: 51.3M. Cumulative incidence: $27/10^5$

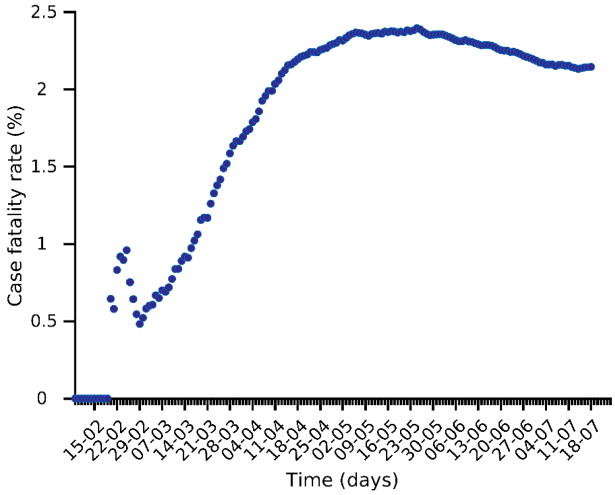


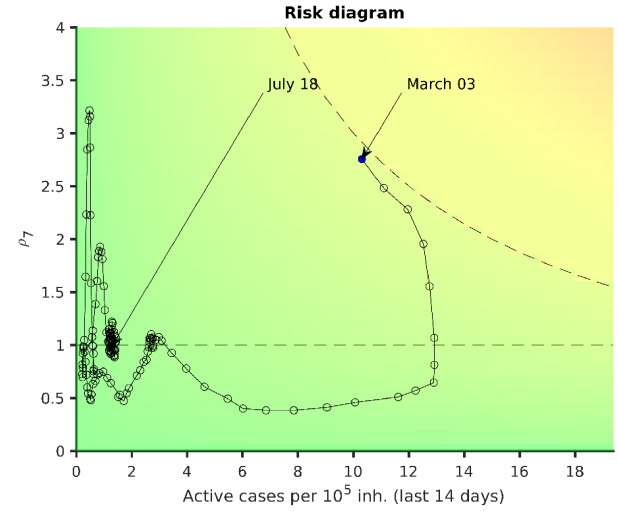


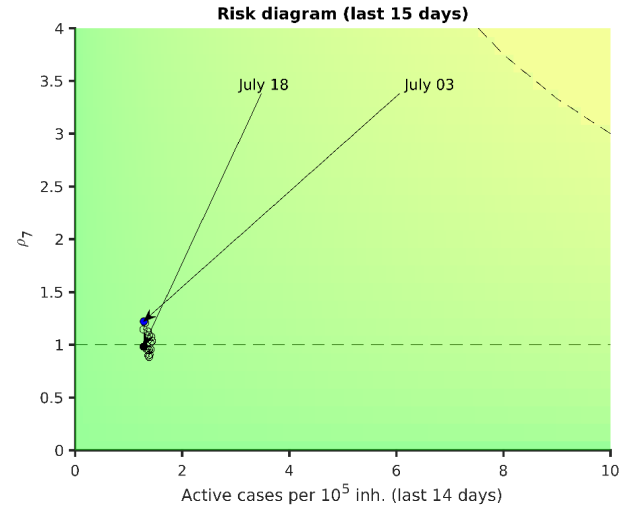




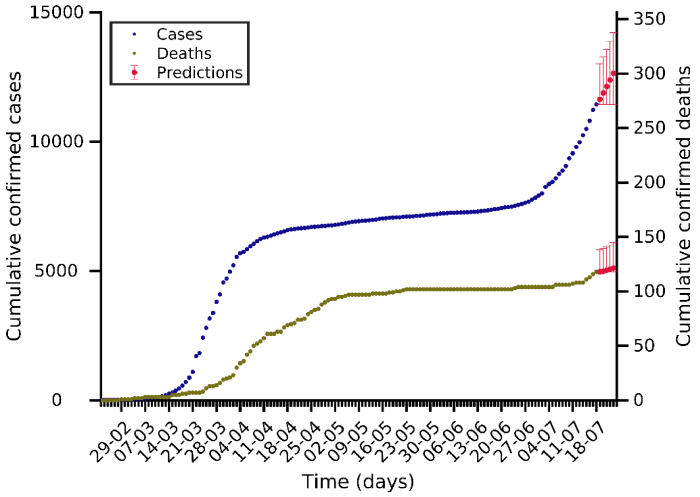


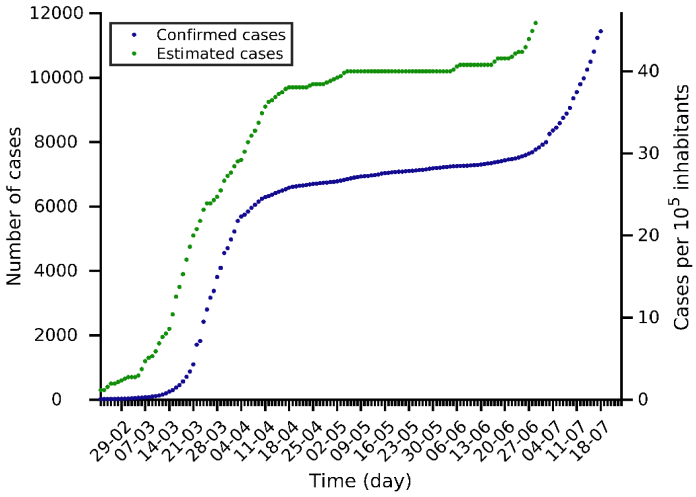


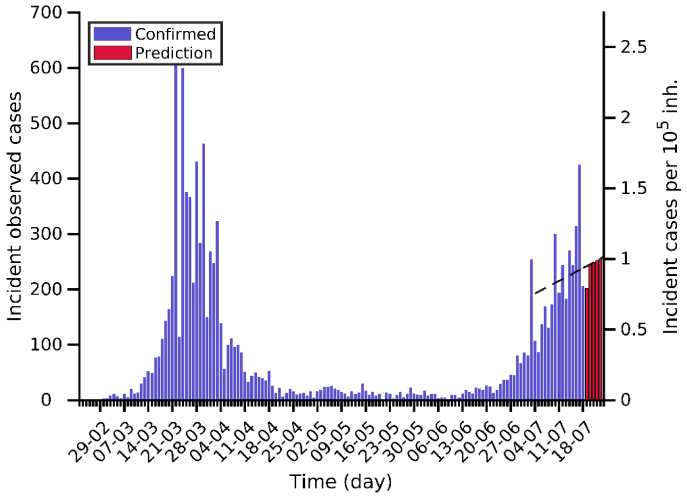


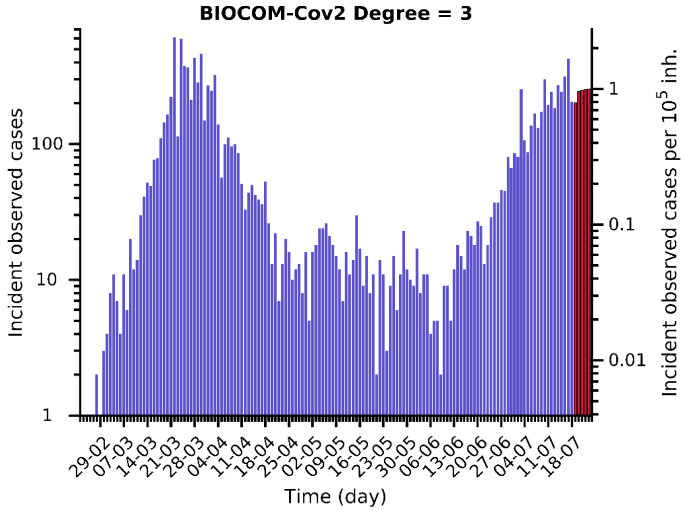


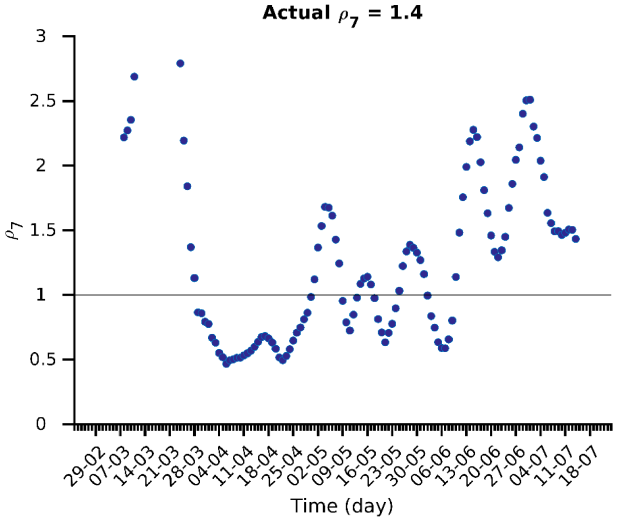
Australia 18-07-2020. Pop: 25.5M. Cumulative incidence: 45/10⁵

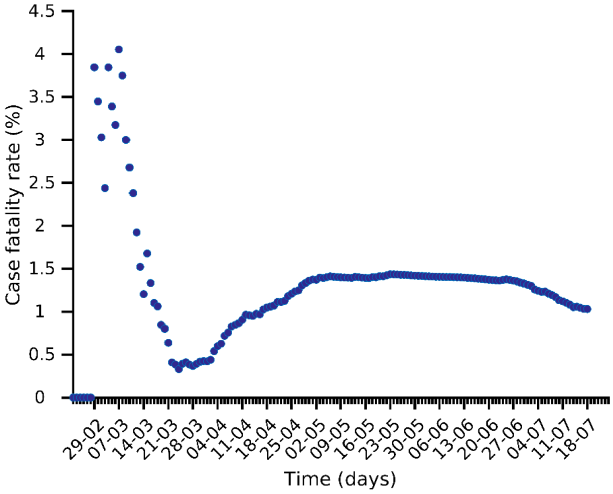


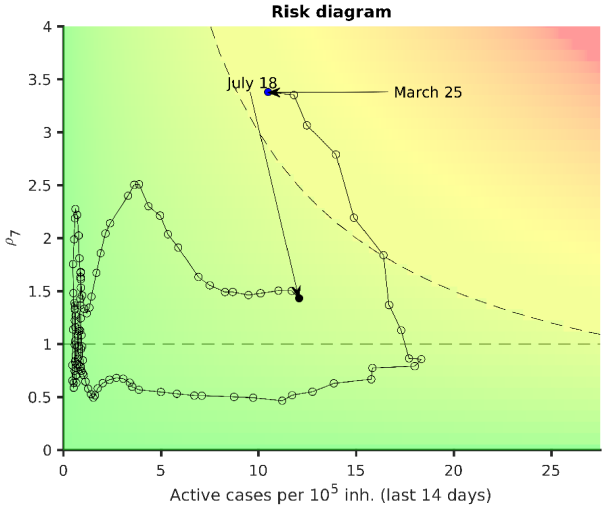


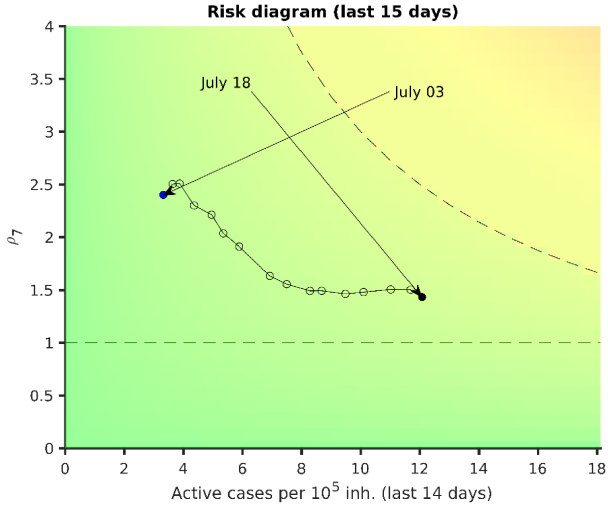




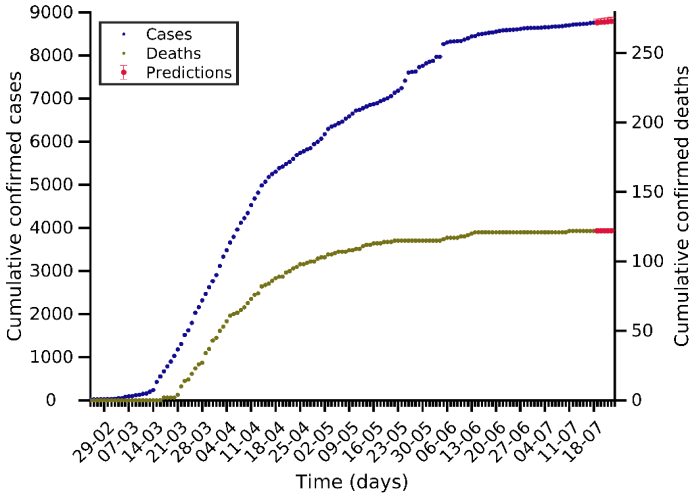


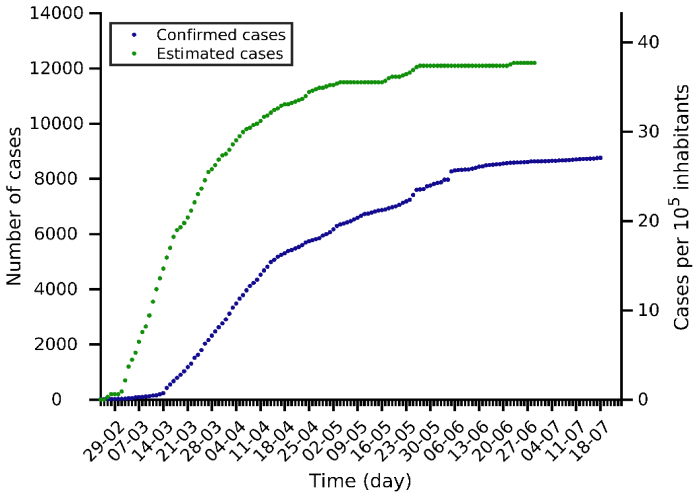


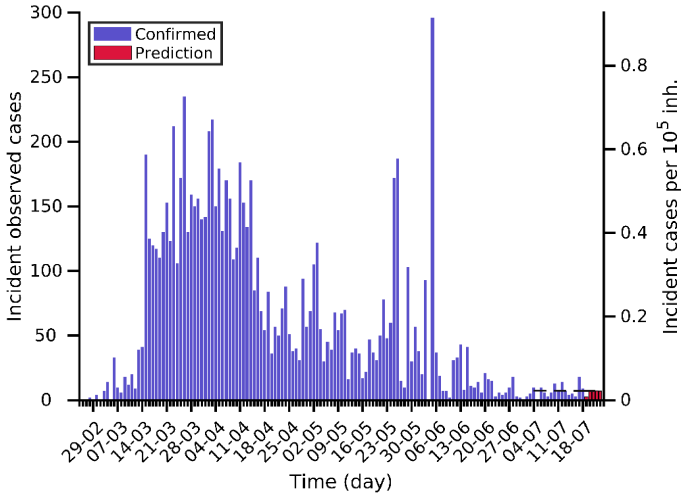


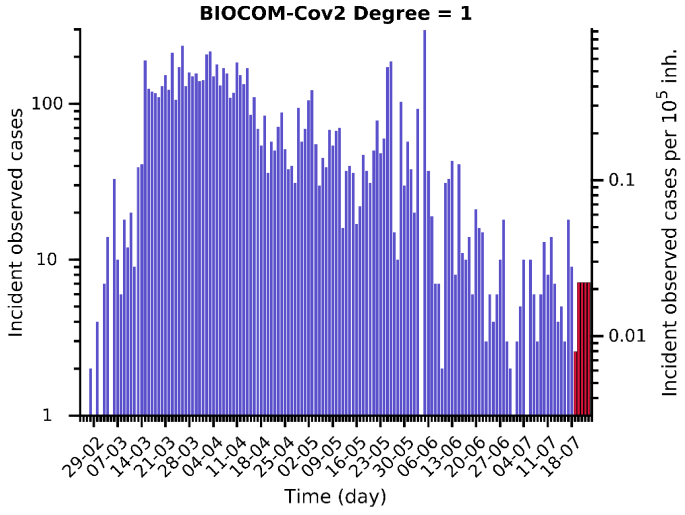


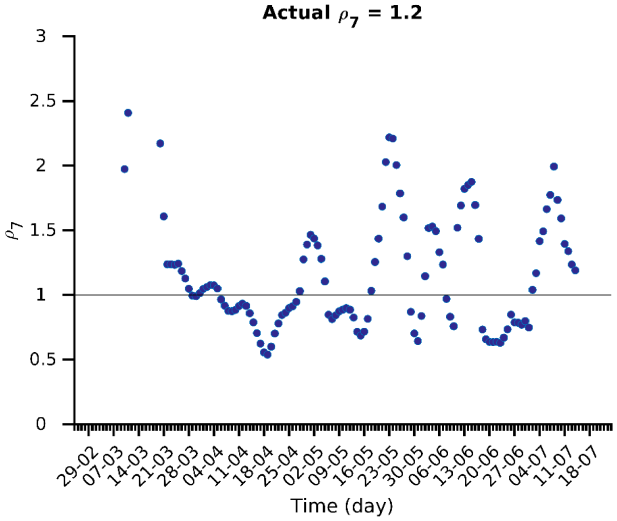
Malaysia 18-07-2020. Pop: 32.4M. Cumulative incidence: 27/10^5

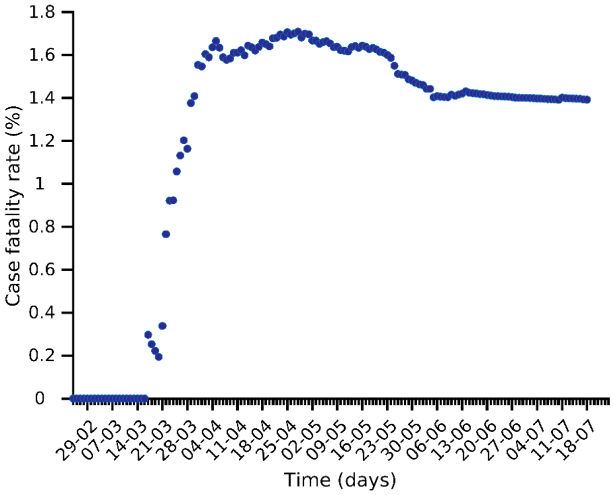


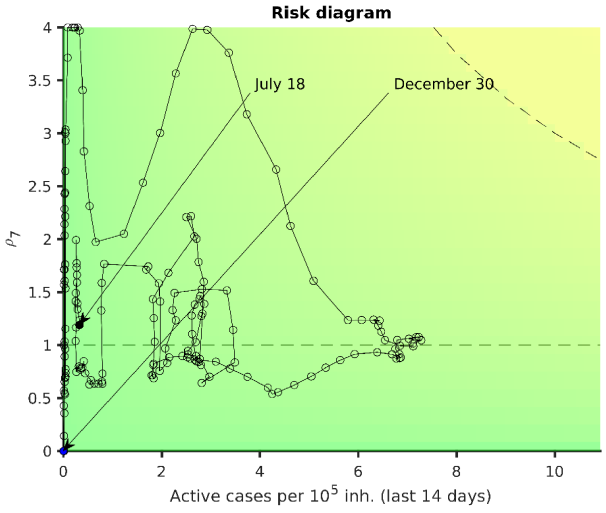


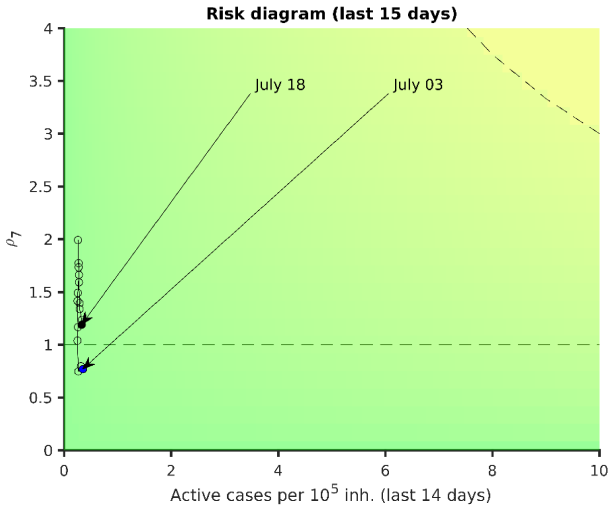




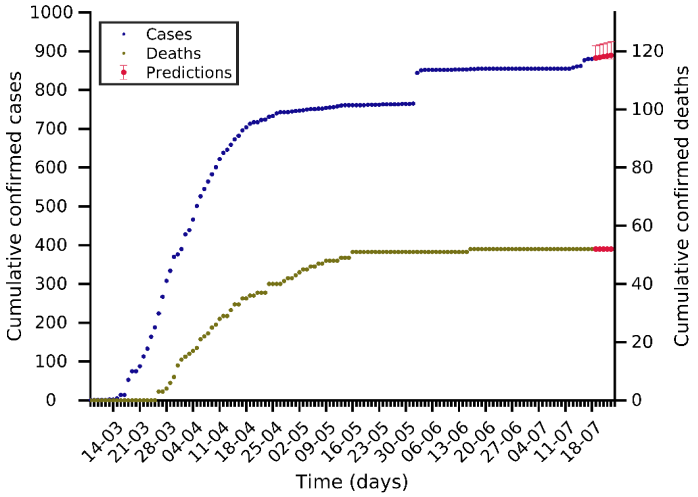


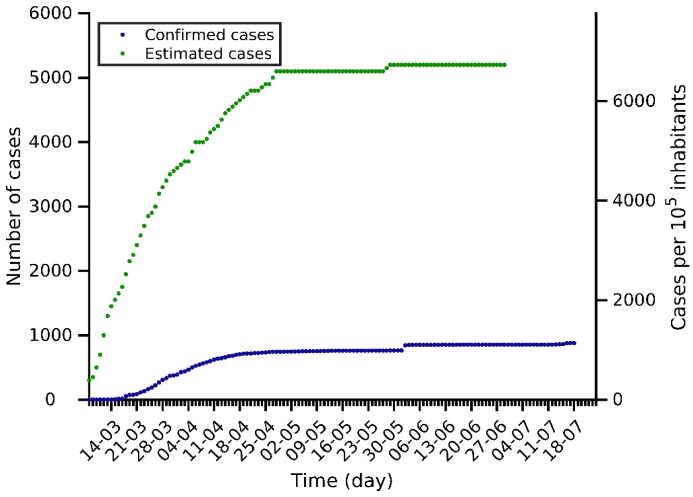


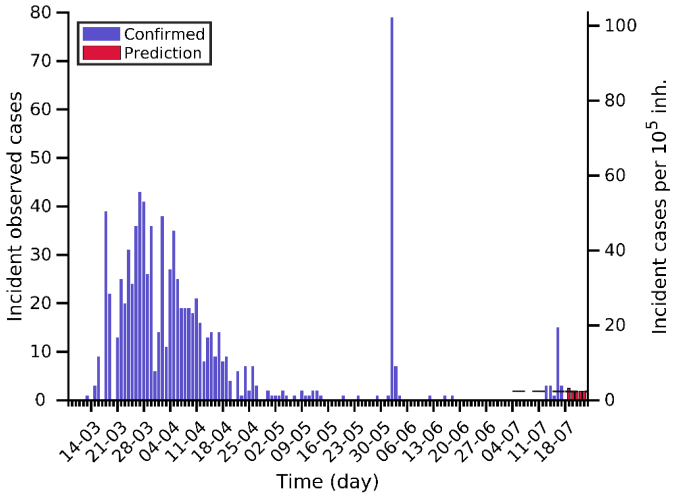


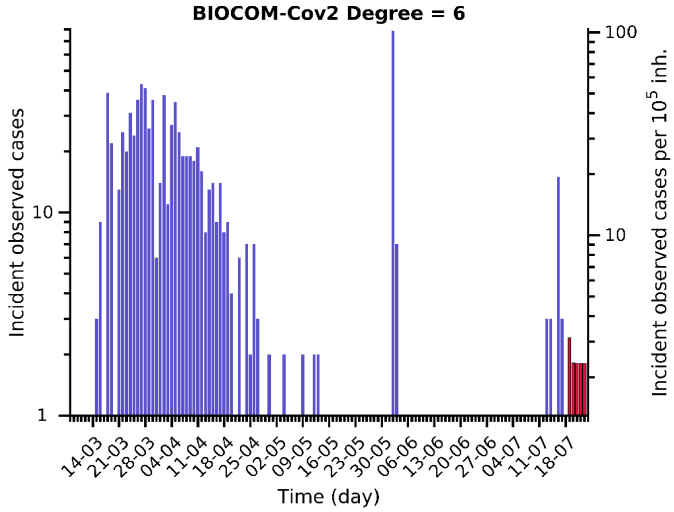


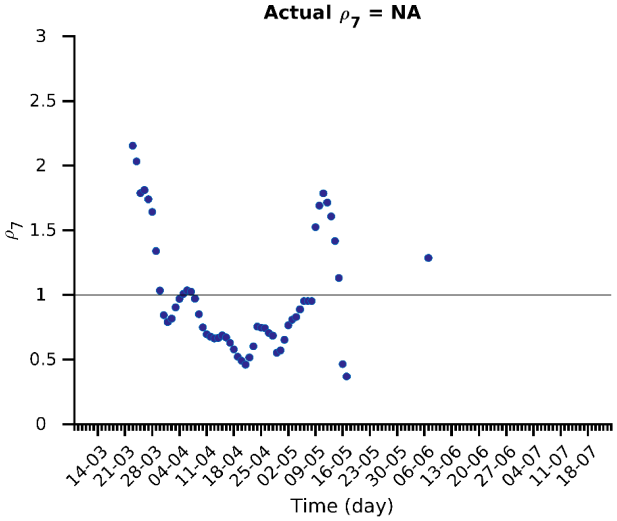
Andorra 18-07-2020. Pop: 0.1M. Cumulative incidence: 1139/10⁵

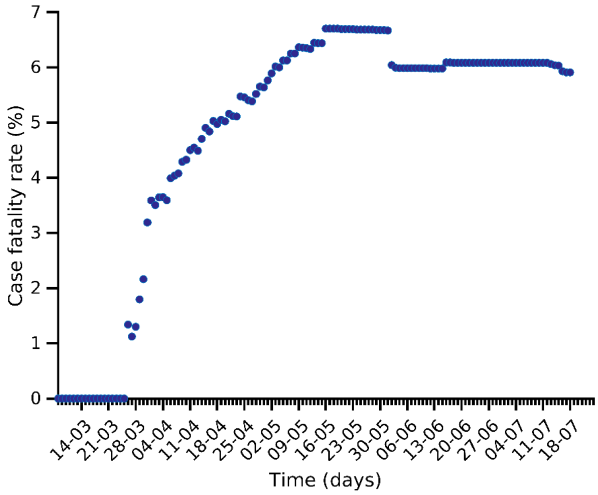


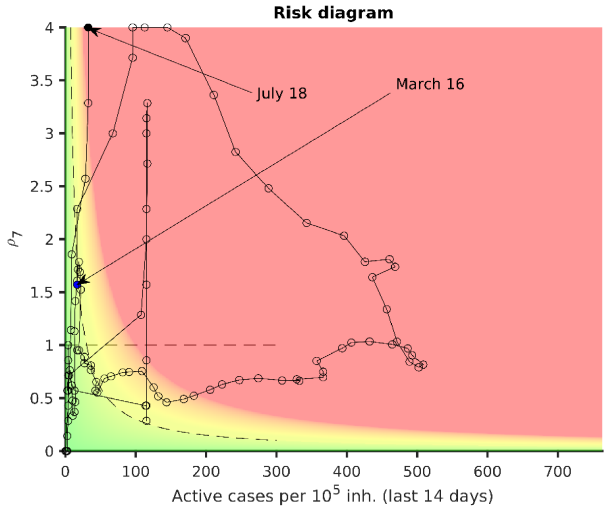


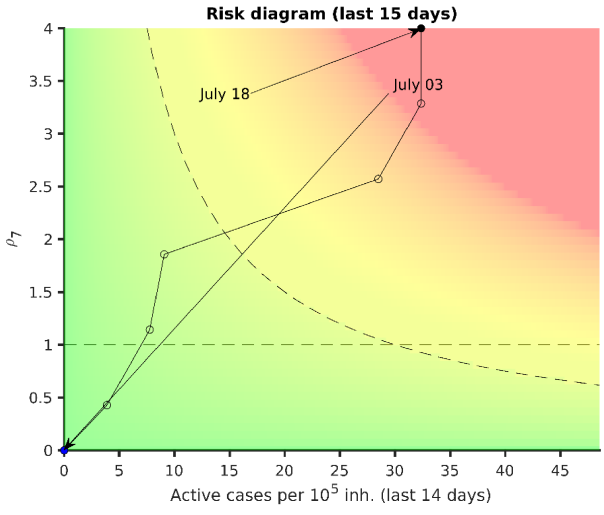








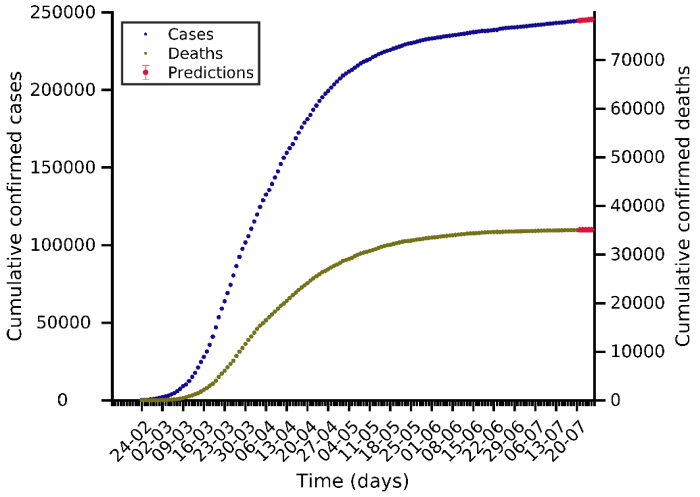


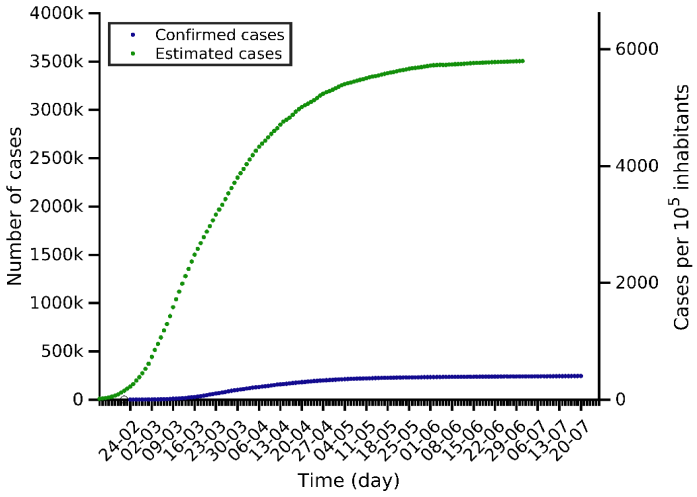


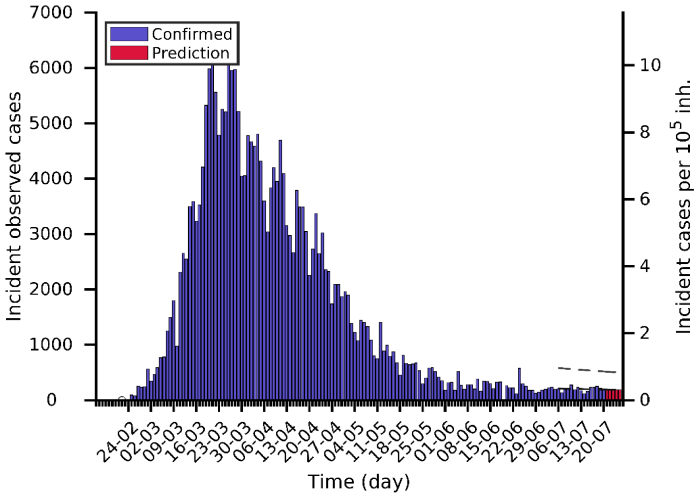
(3) Analysis and prediction of COVID-19 for Italy and its regions

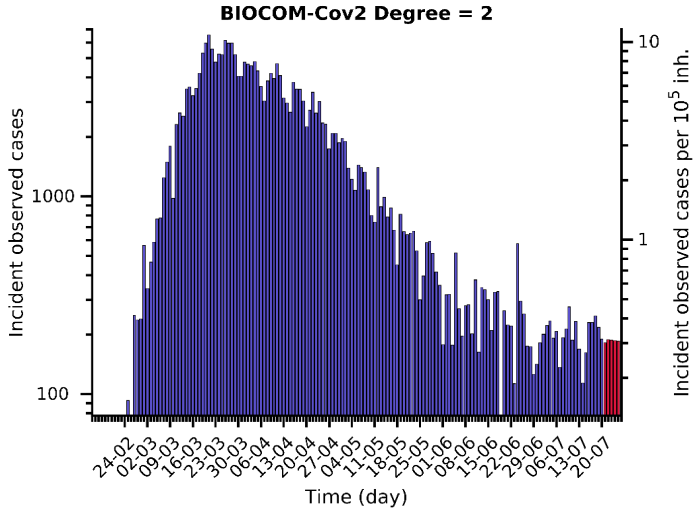
Data obtained from: https://github.com/pcm-dpc/COVID-19/tree/master/dati-andamento-nazionale

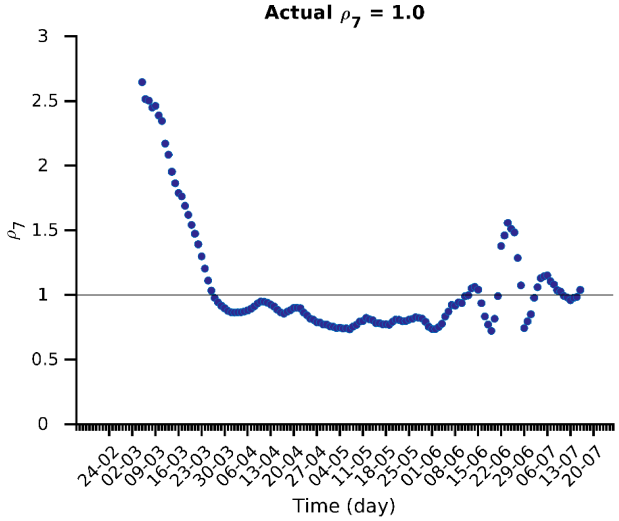
Italy 20-07-2020. Pop: 60.5M. Cumulative incidence: 405/10⁵

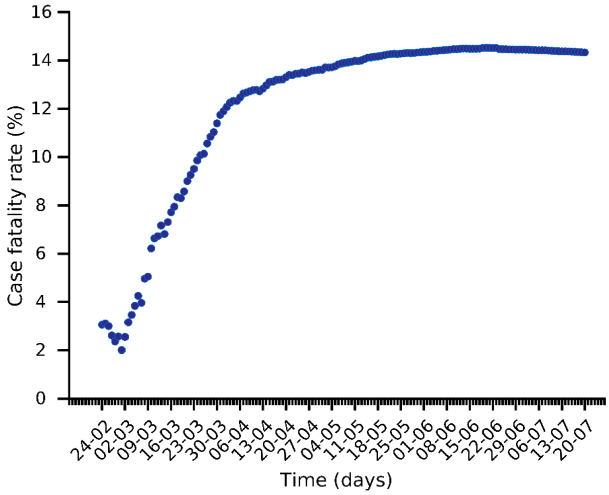


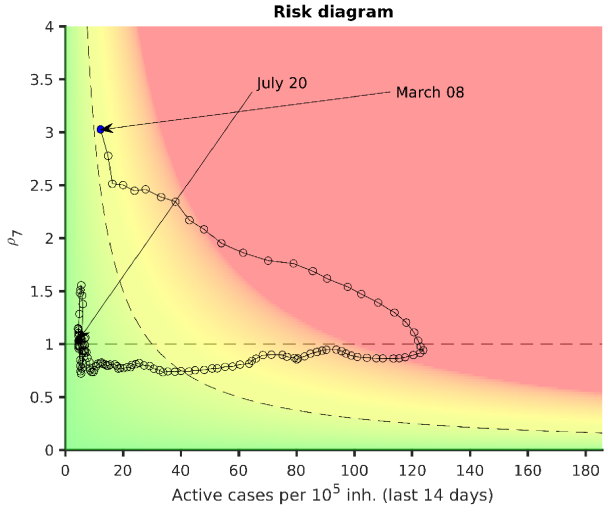


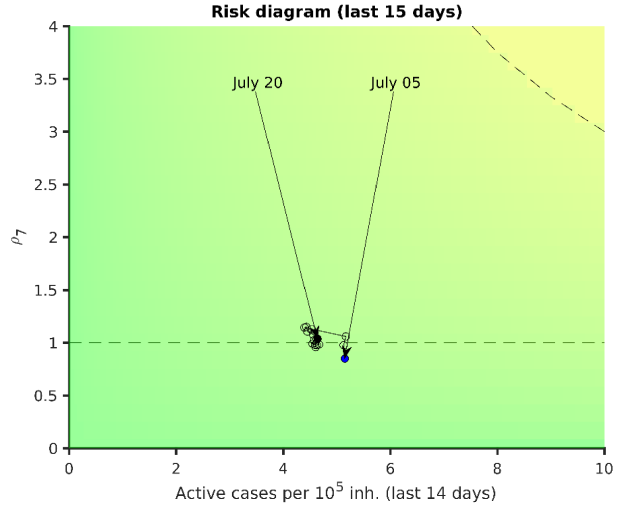




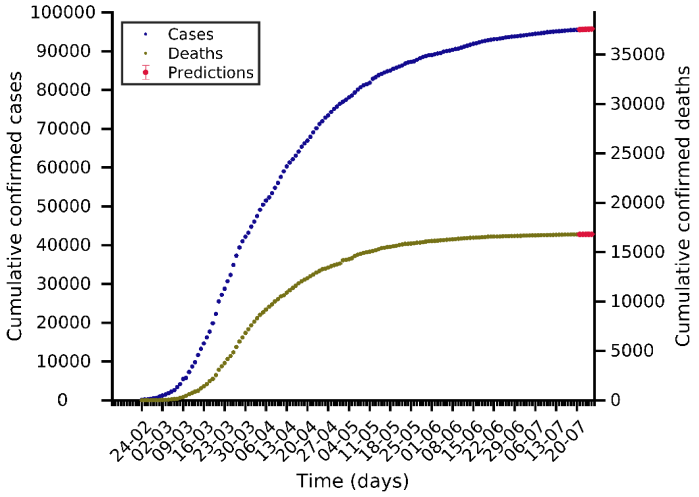


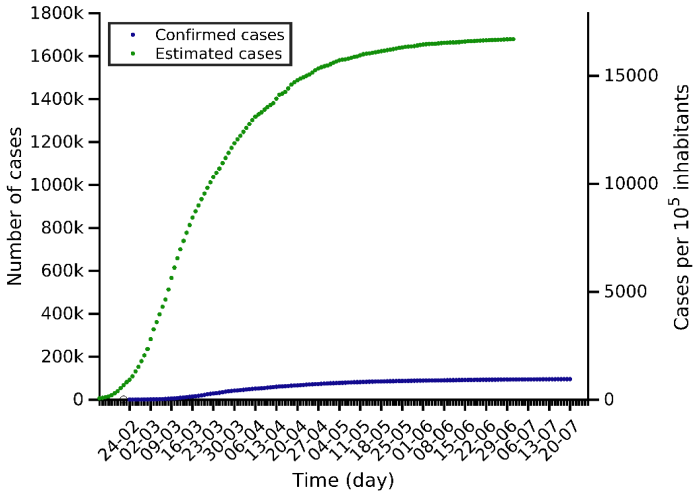


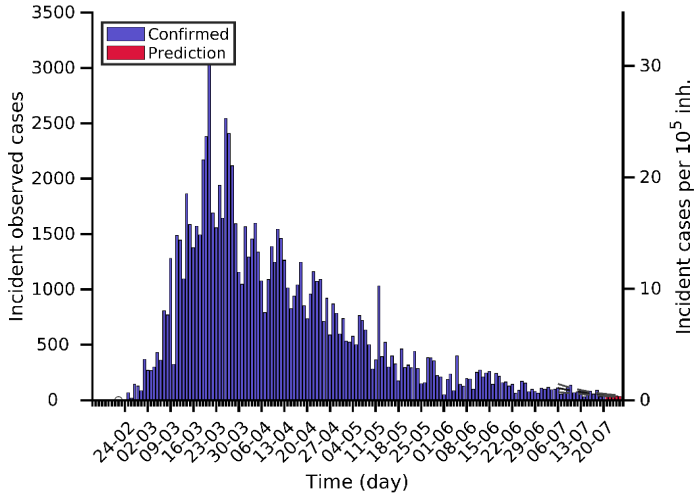


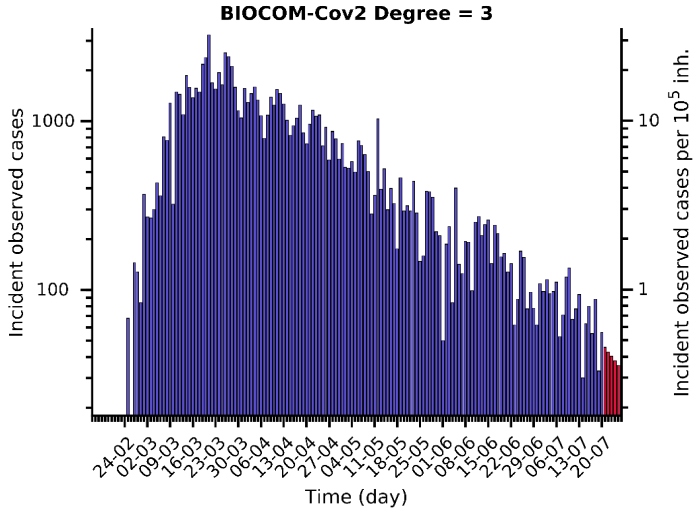


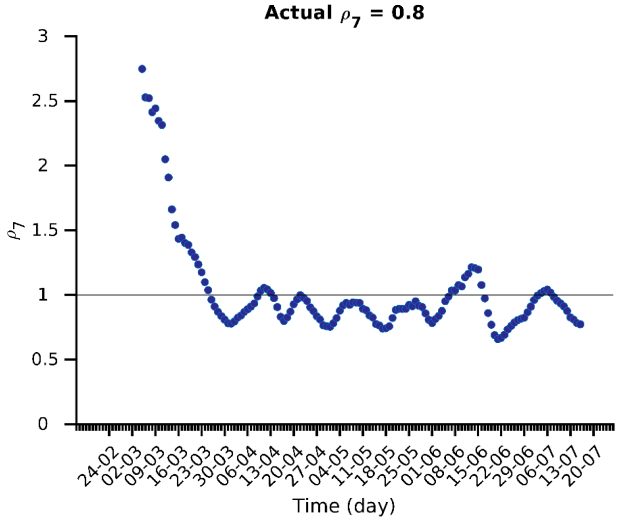
Lombardia 20-07-2020. Pop: 10.1M. Cumulative incidence: 950/10⁵

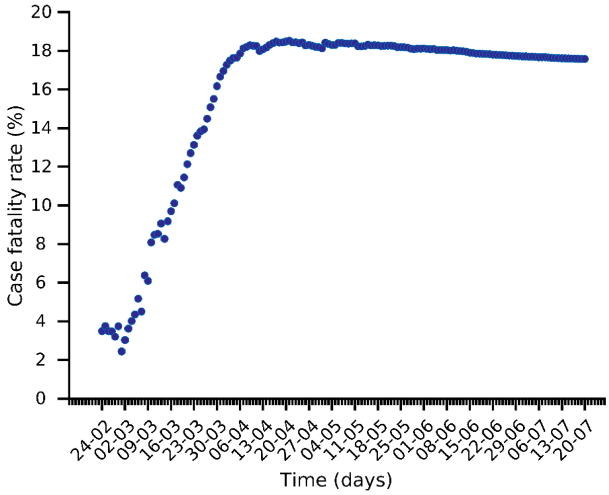


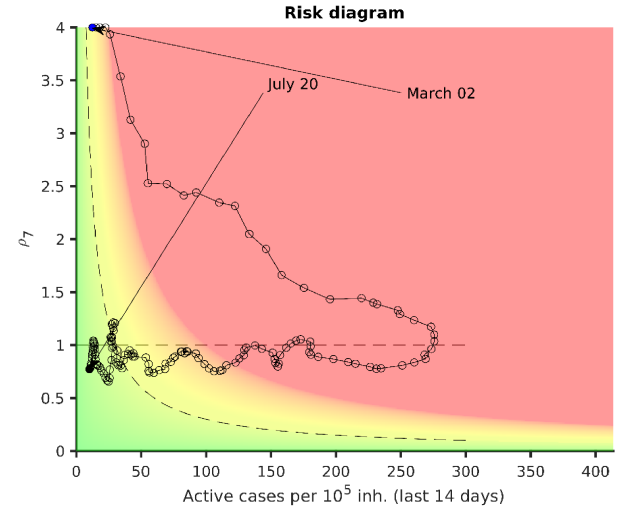


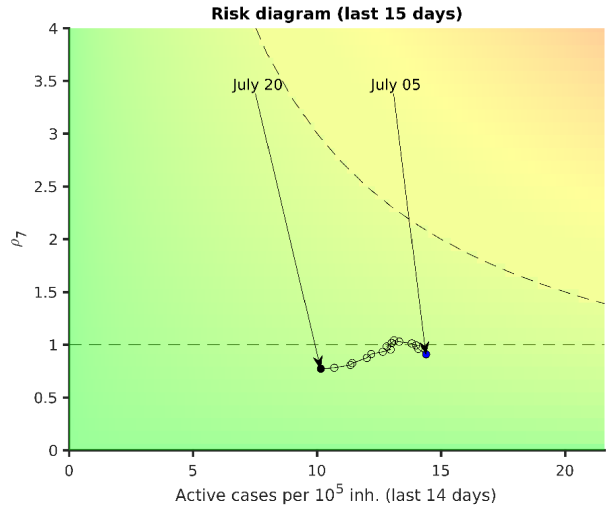




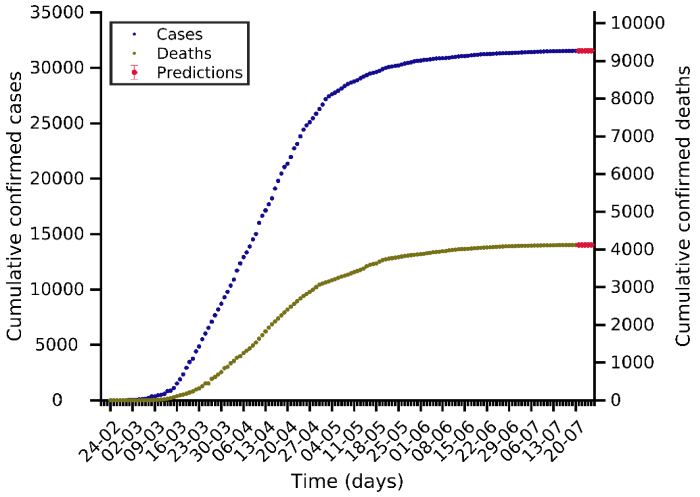


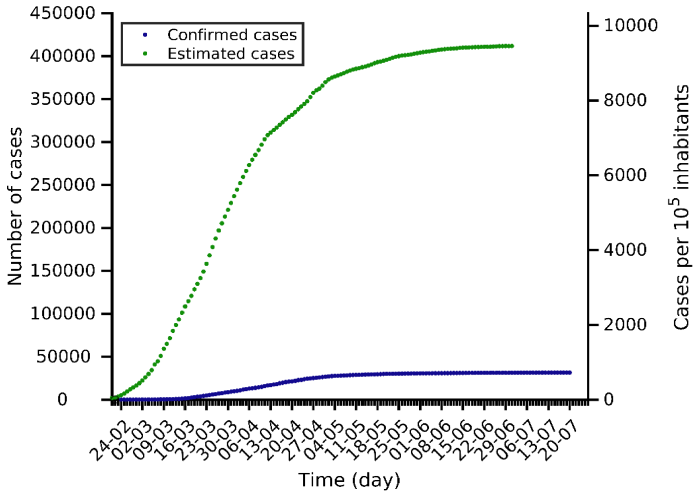


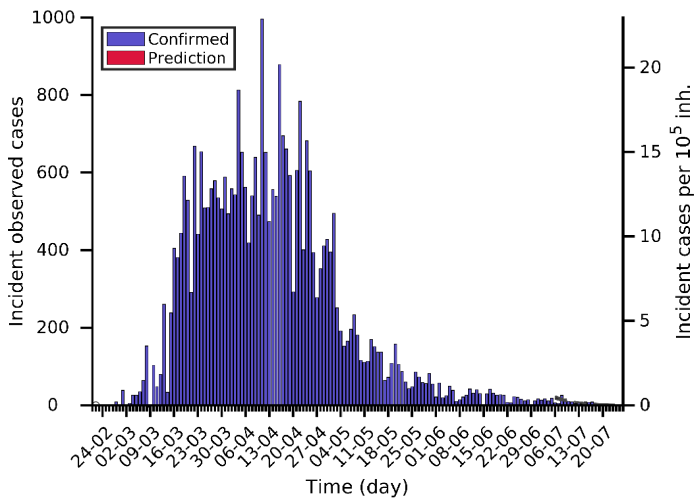


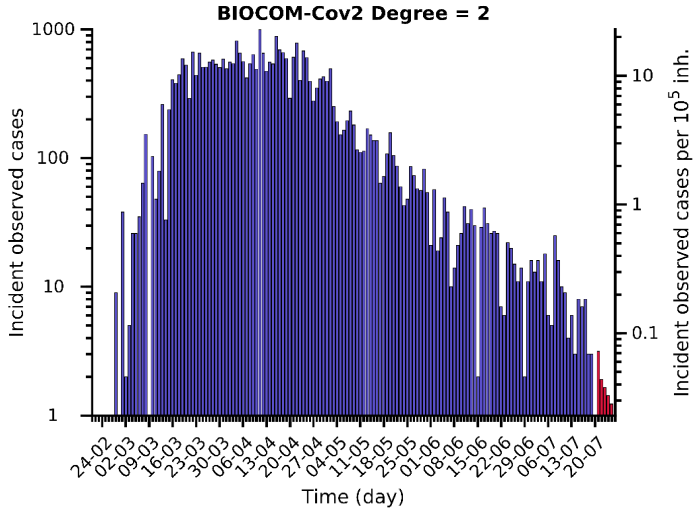


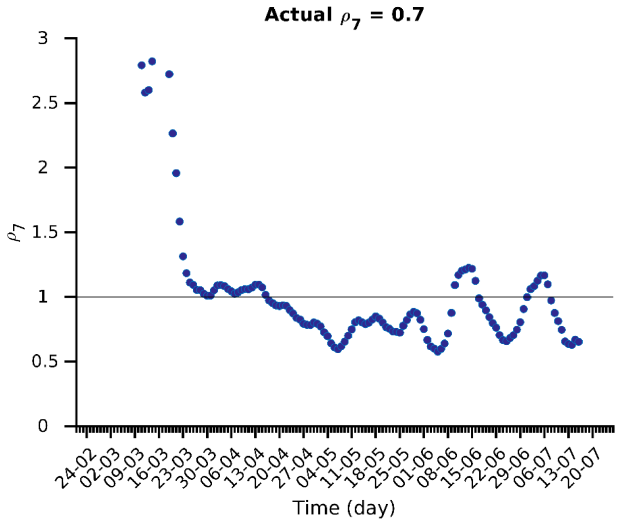
Piemonte 20-07-2020. Pop: 4.4M. Cumulative incidence: 724/10⁵

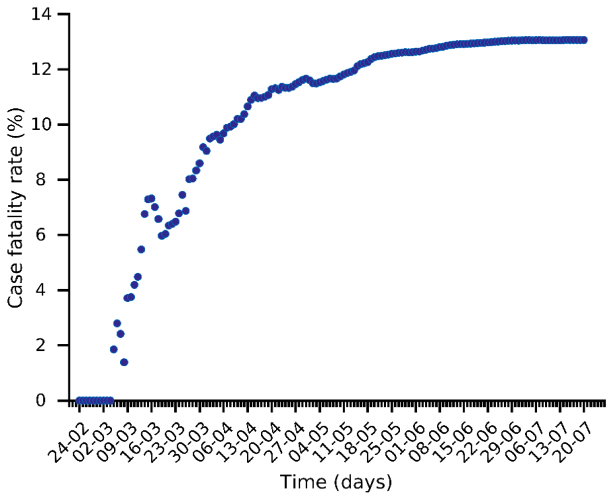


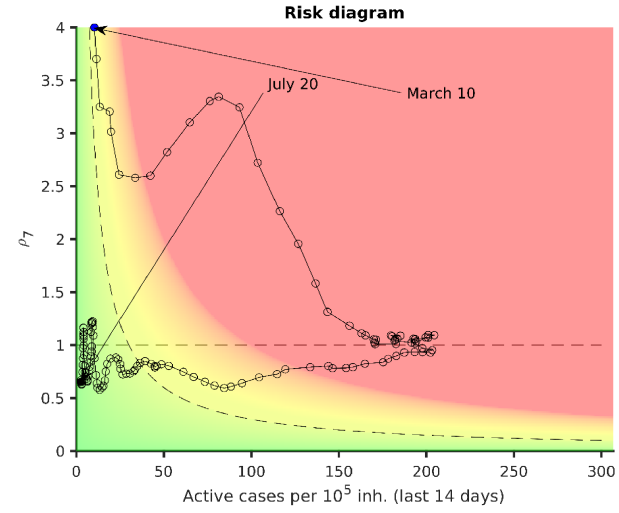


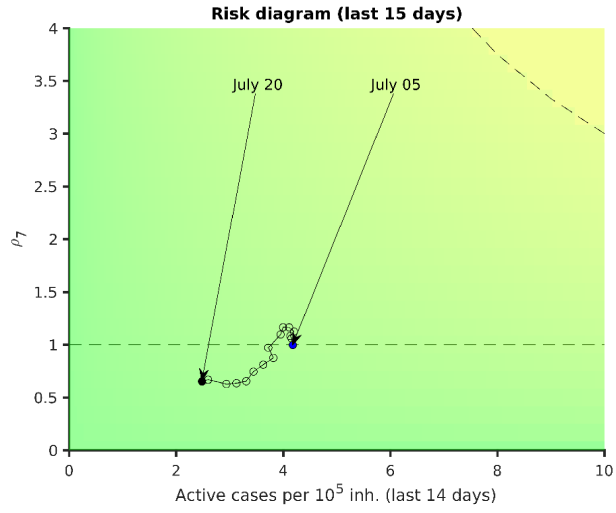




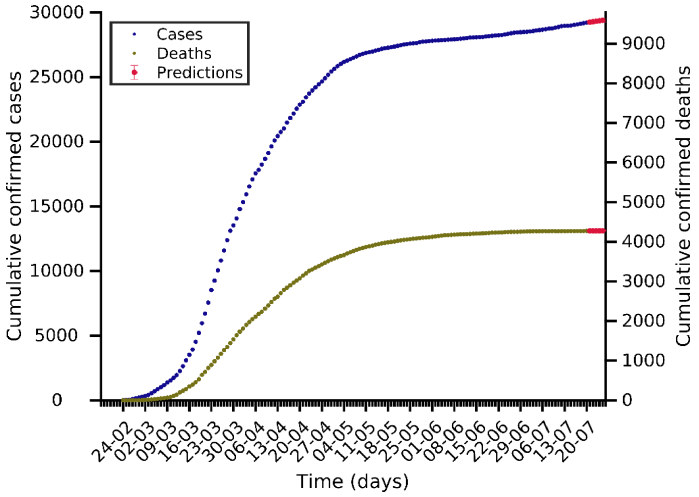


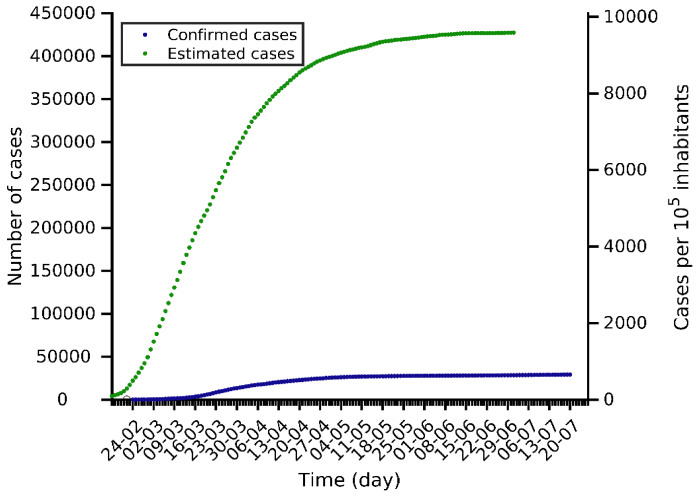


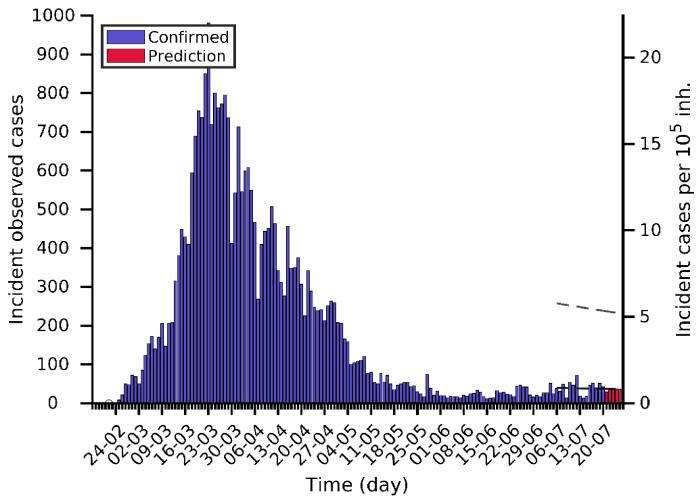


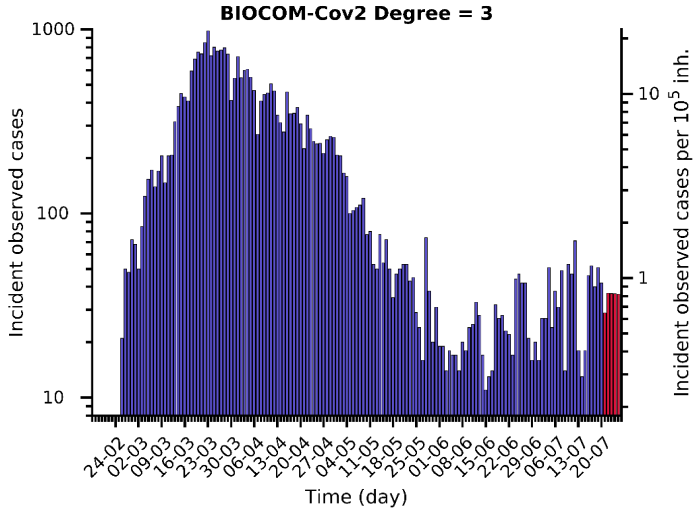


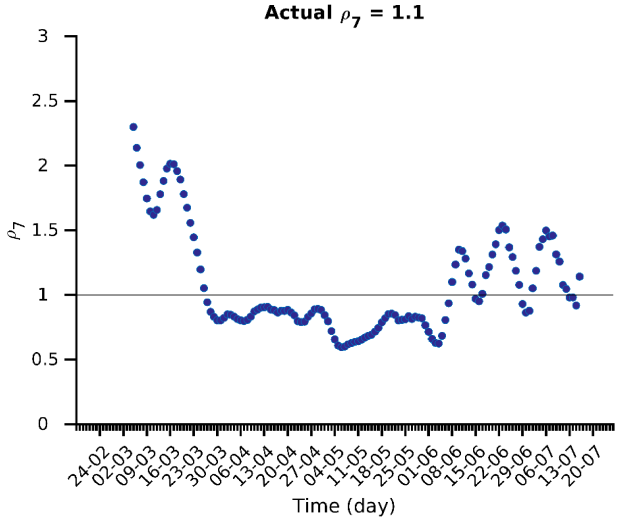
Emilia Romagna 20-07-2020. Pop: 4.5M. Cumulative incidence: 655/10⁵

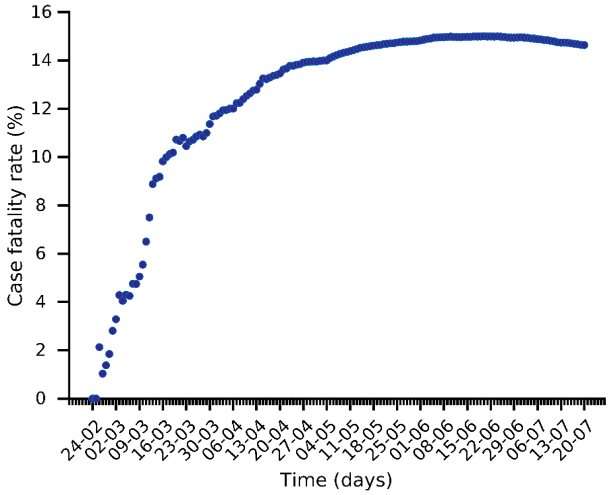


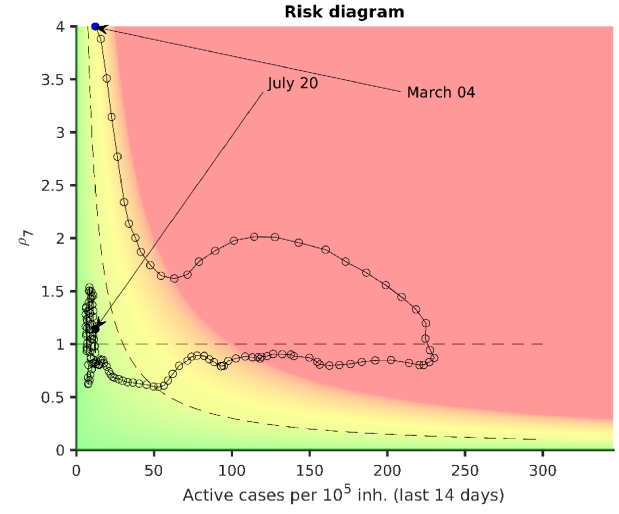


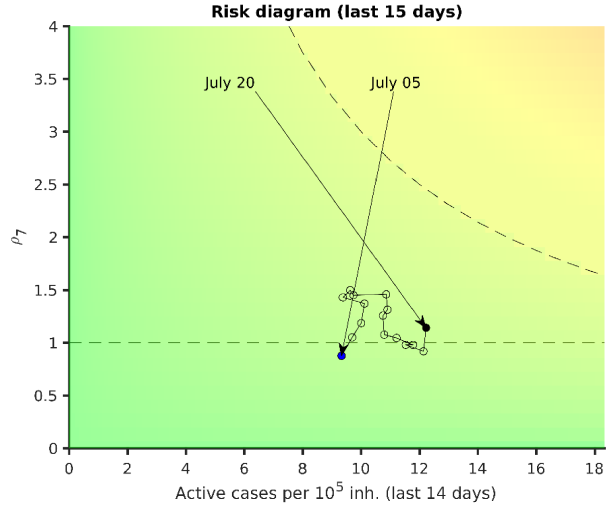




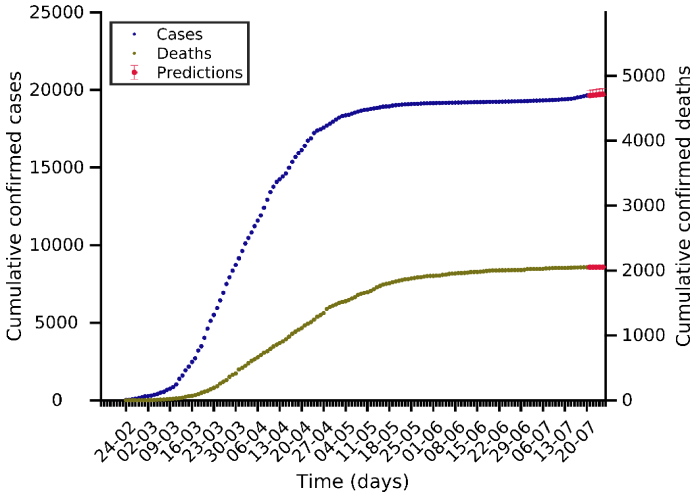


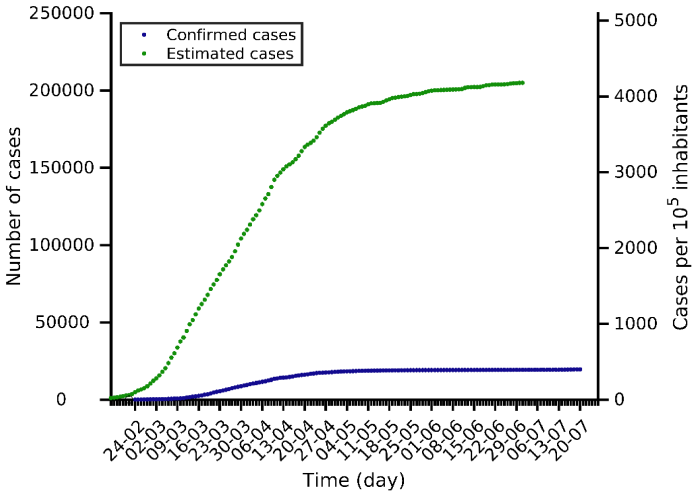


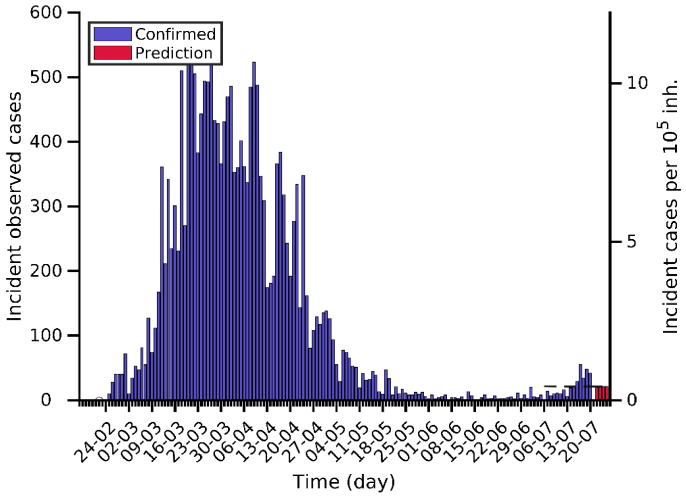


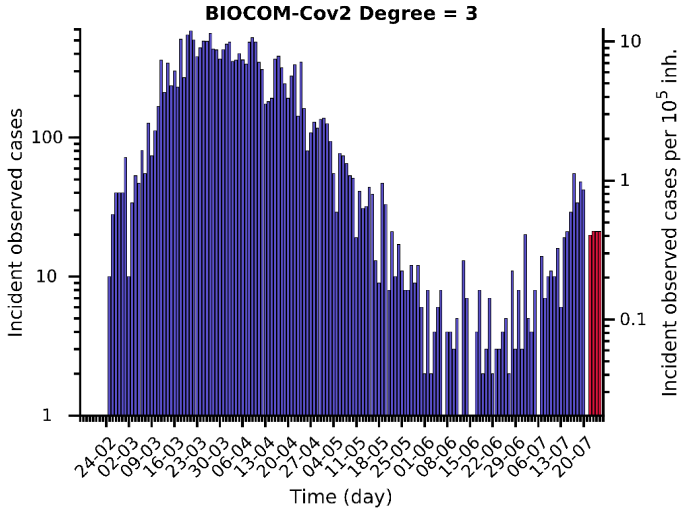


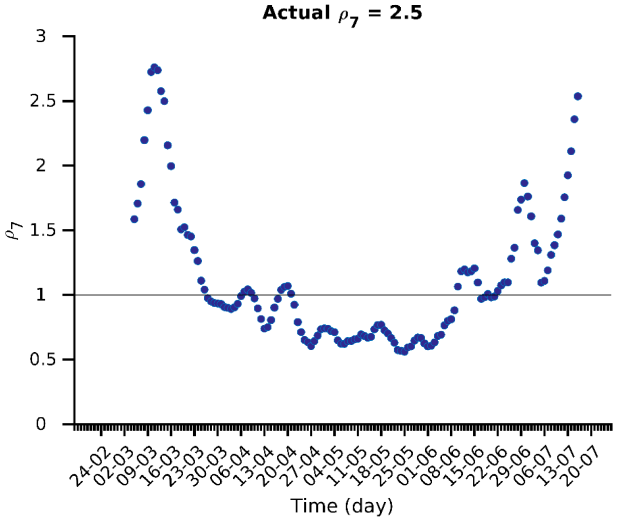
Veneto 20-07-2020. Pop: 4.9M. Cumulative incidence: 401/10⁵

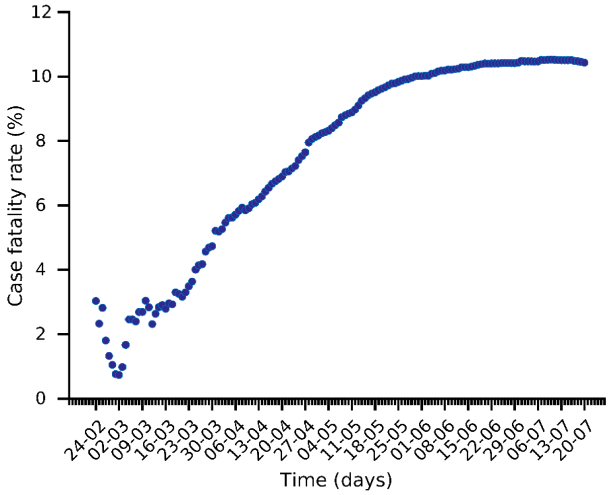


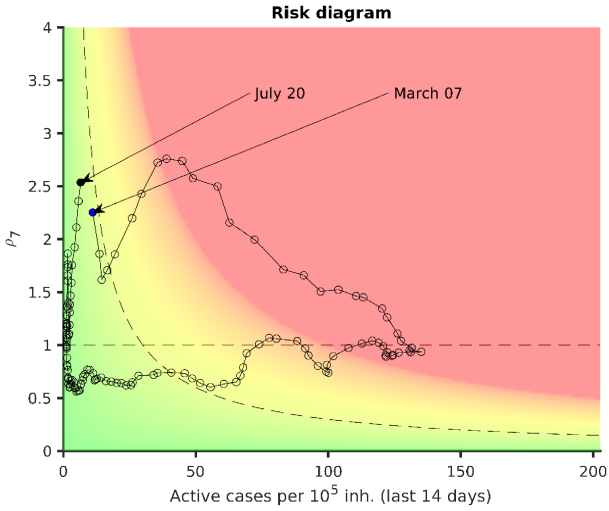


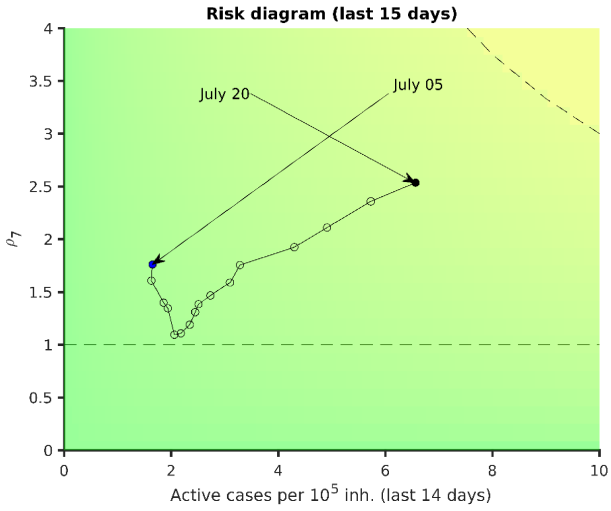




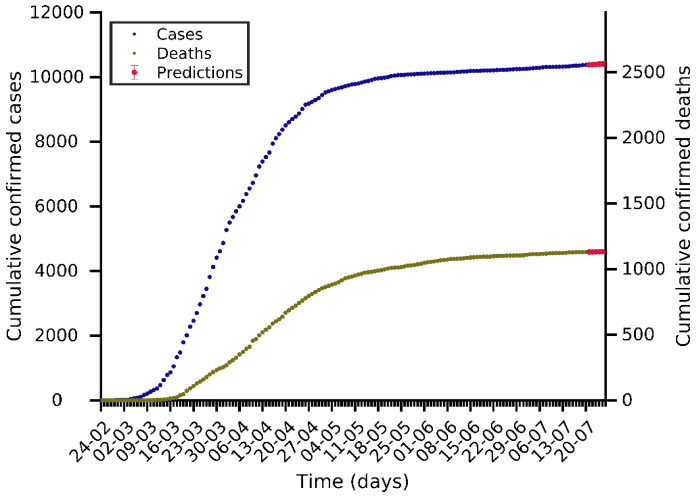


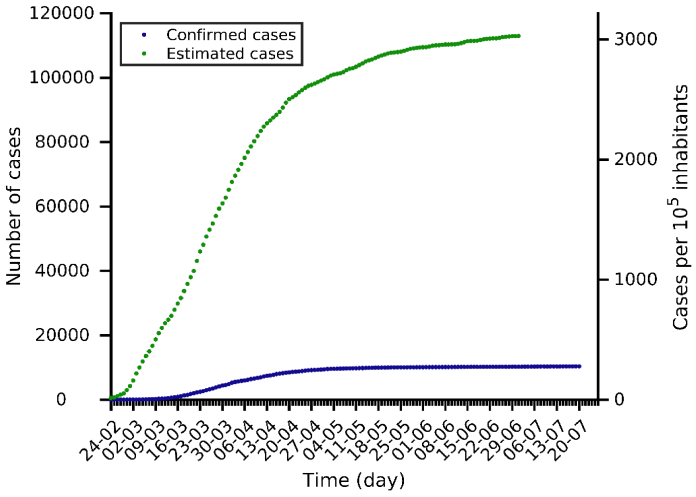


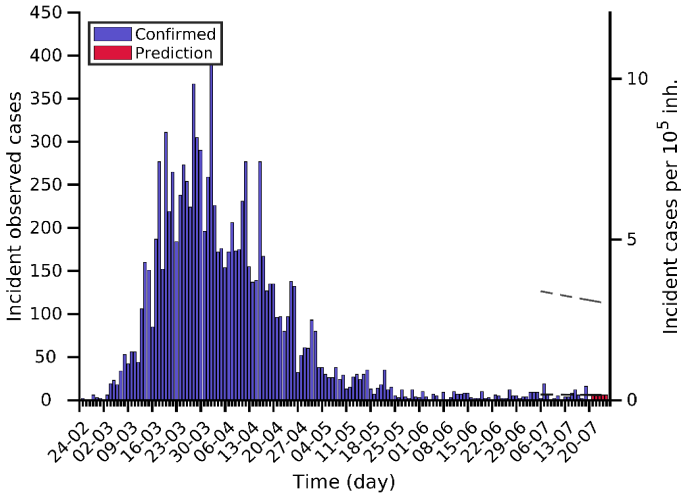


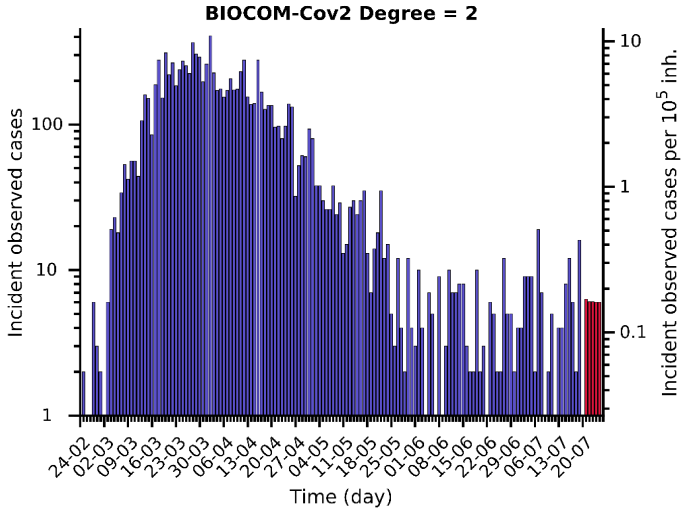


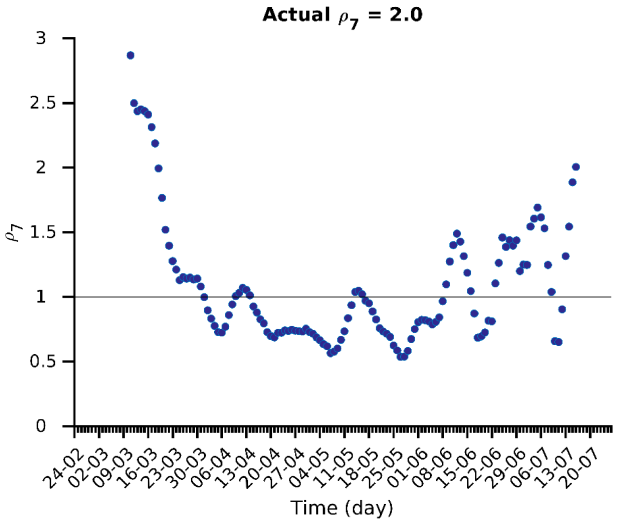
Toscana 20-07-2020. Pop: 3.7M. Cumulative incidence: 278/10⁵

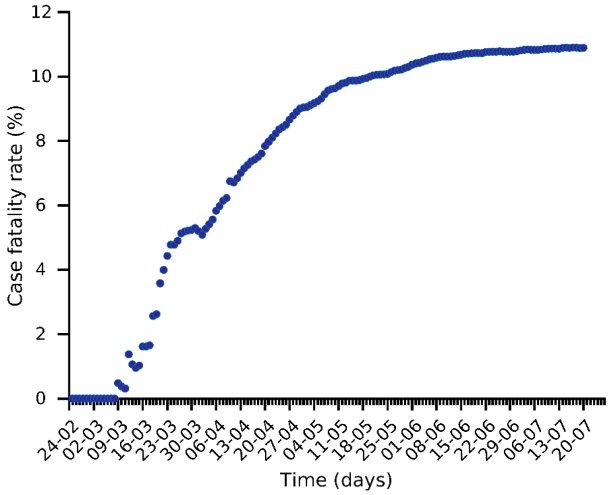


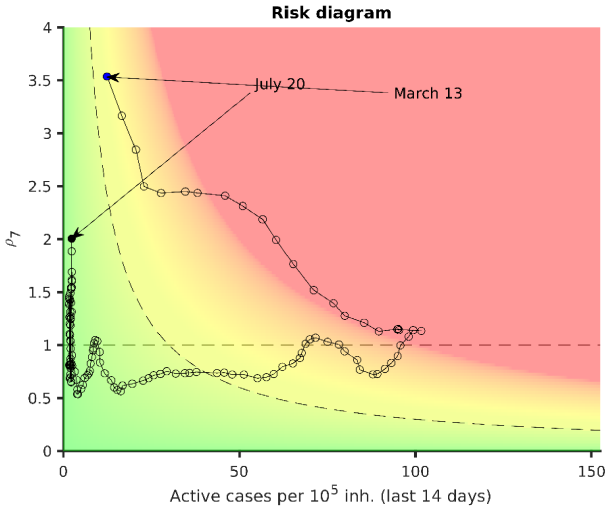


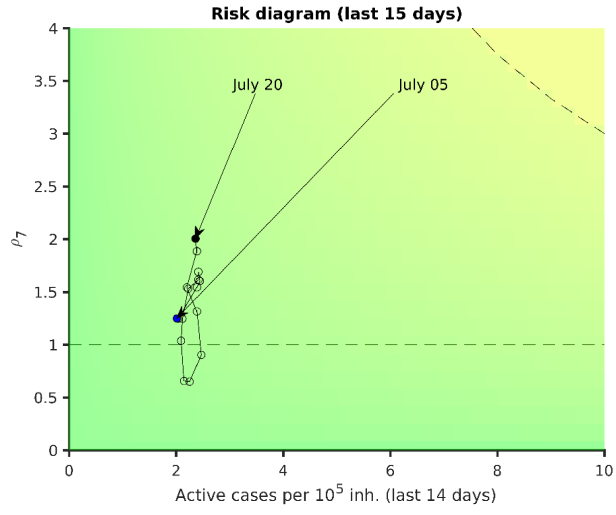




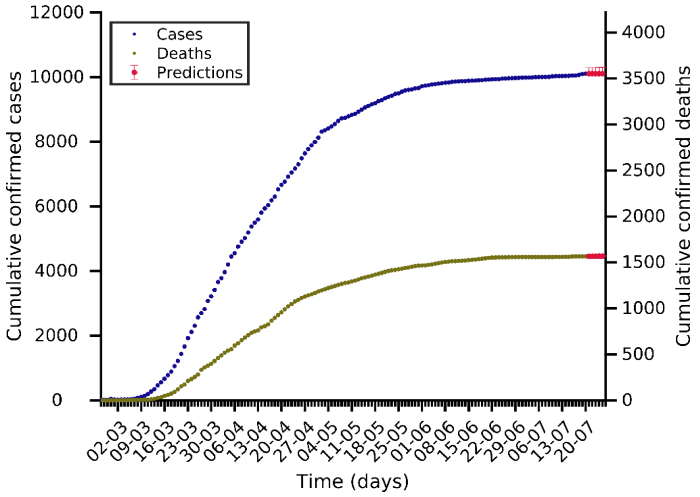


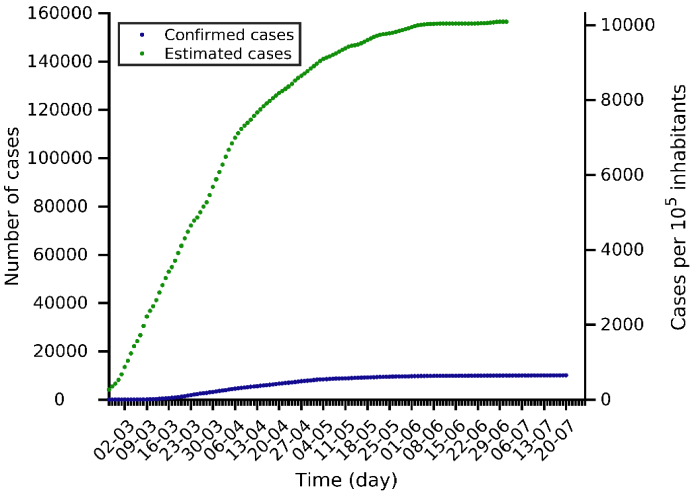


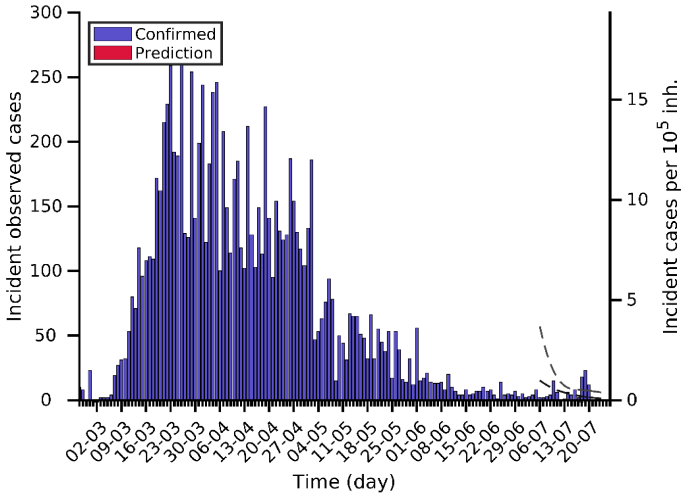


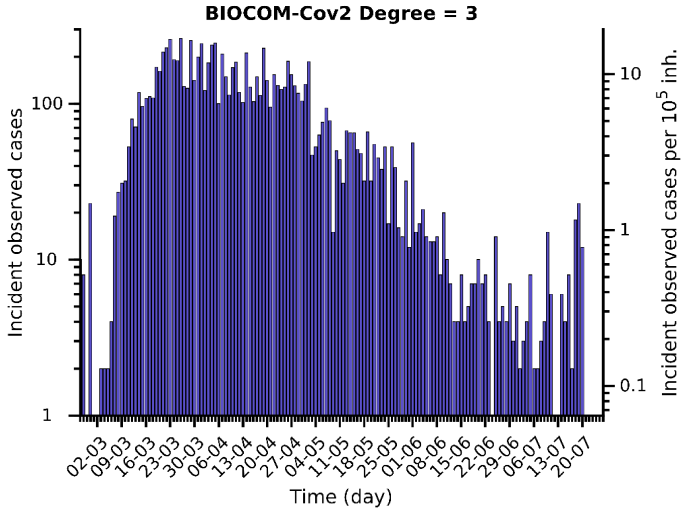


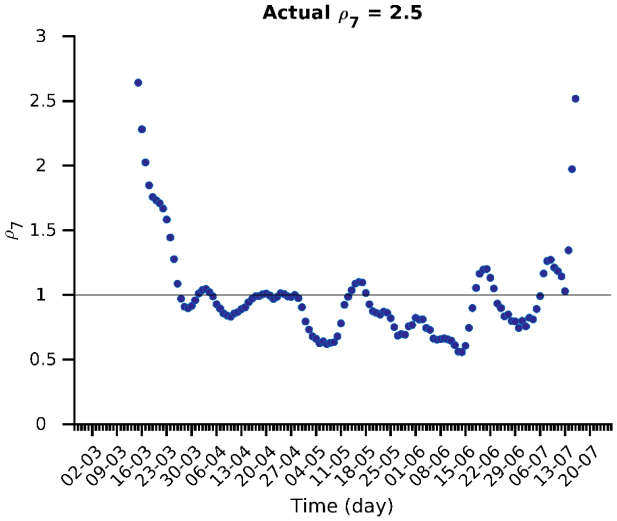
Liguria 20-07-2020. Pop: 1.6M. Cumulative incidence: 652/10⁵

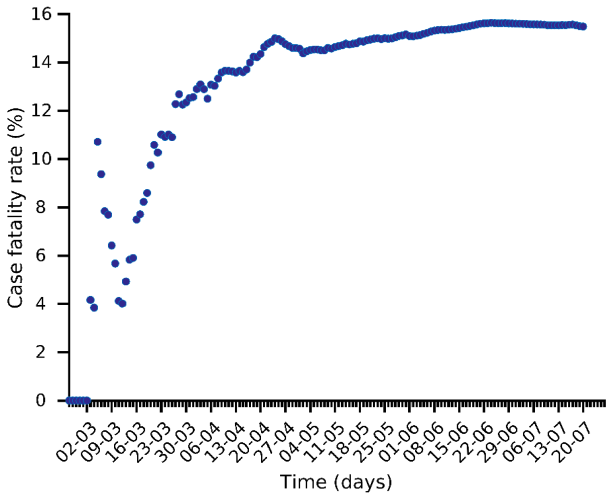


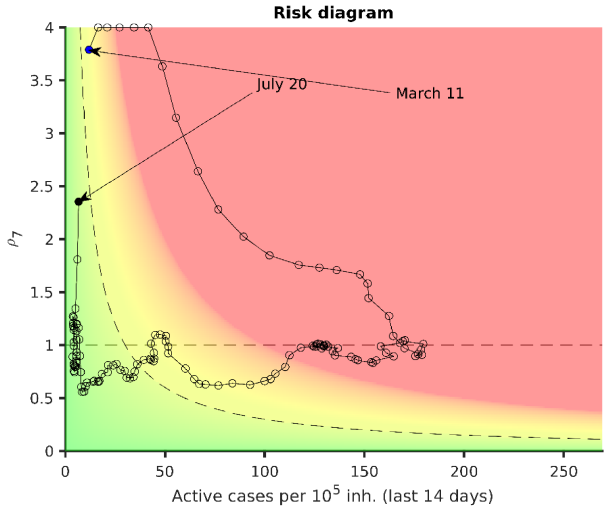


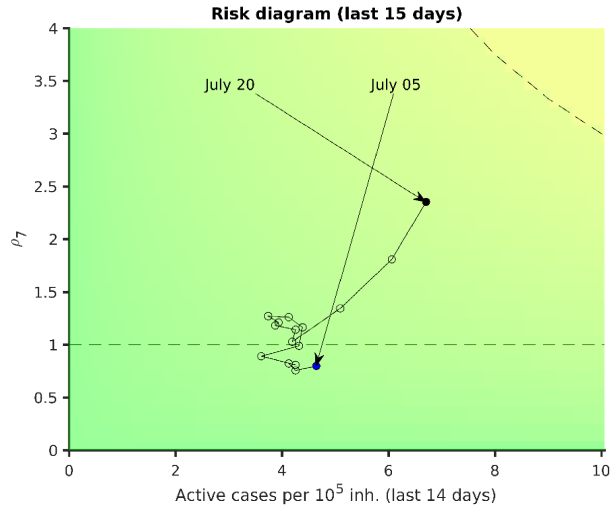




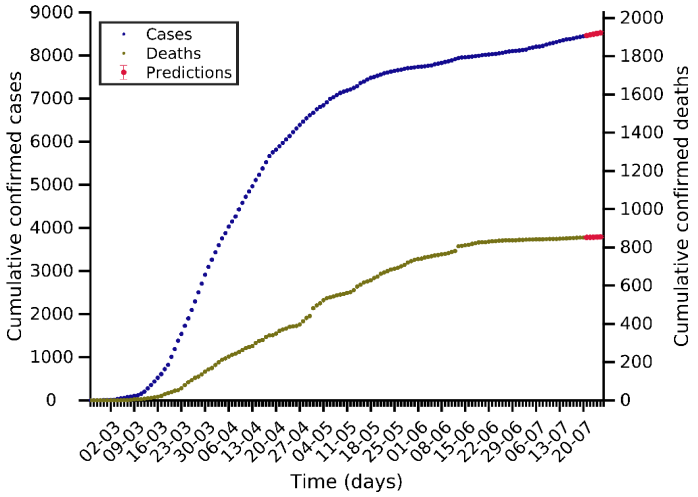


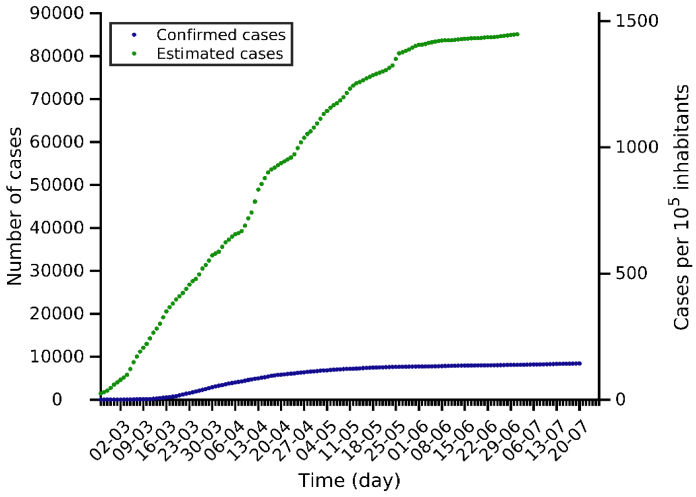


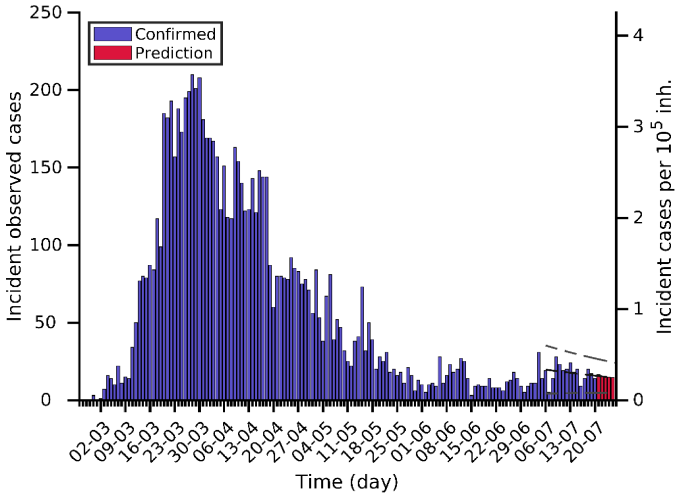


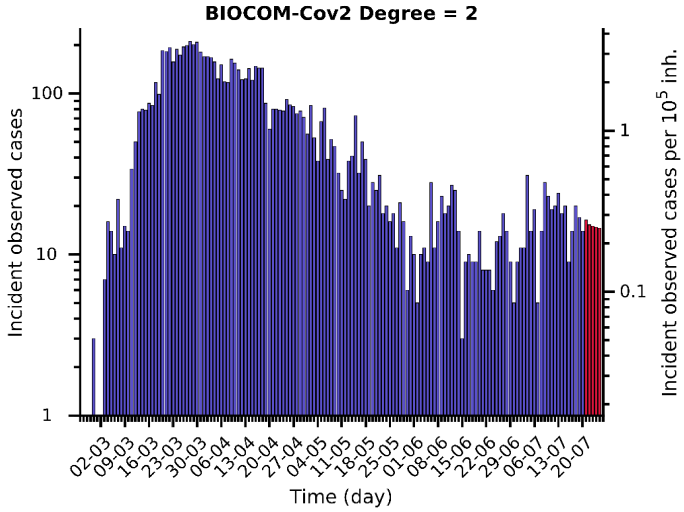


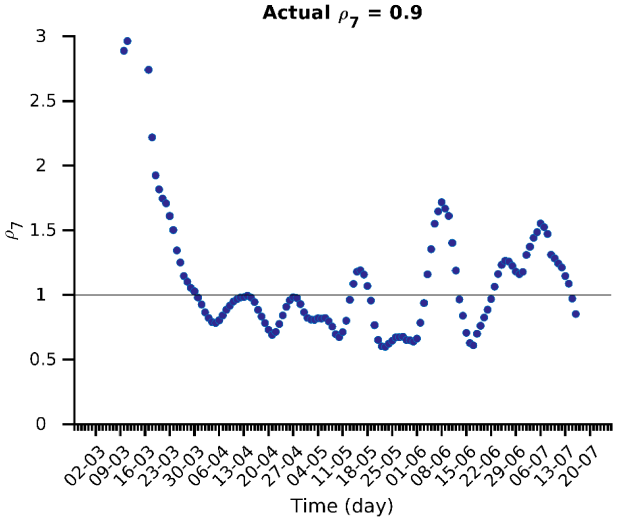
Lazio 20-07-2020. Pop: 5.9M. Cumulative incidence: 144/10^5

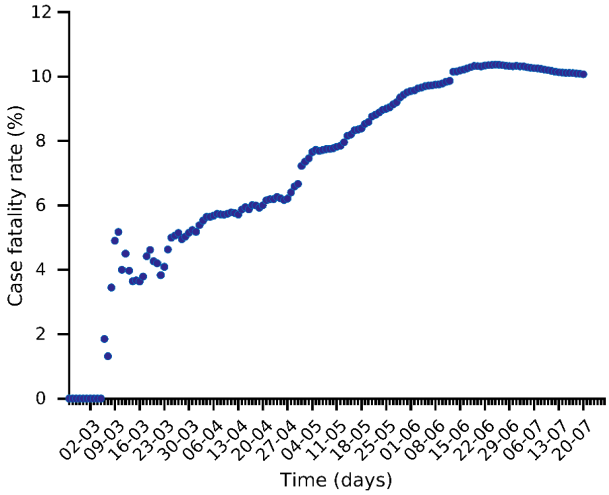


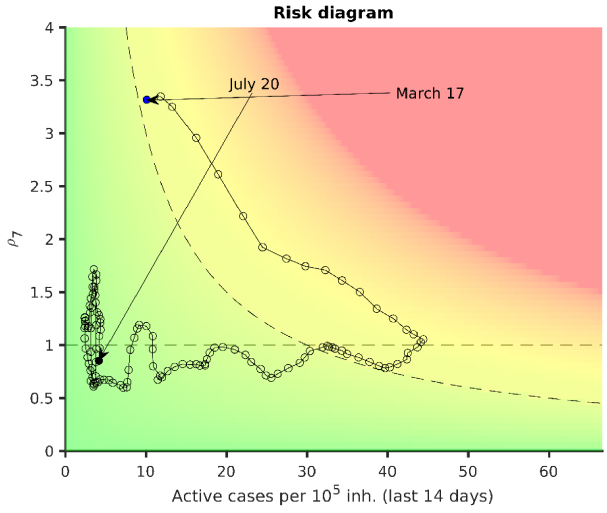


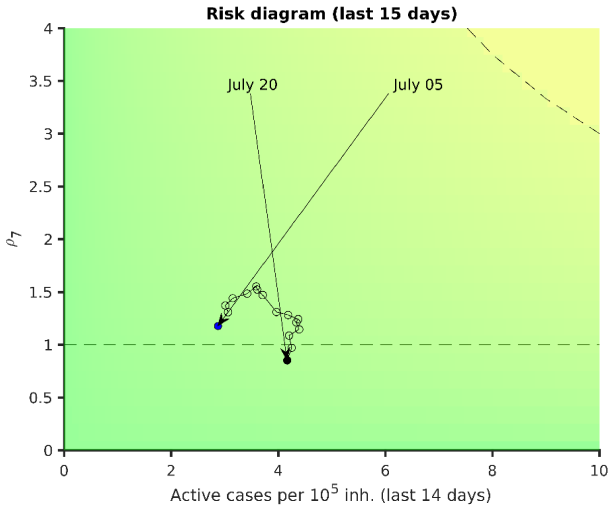




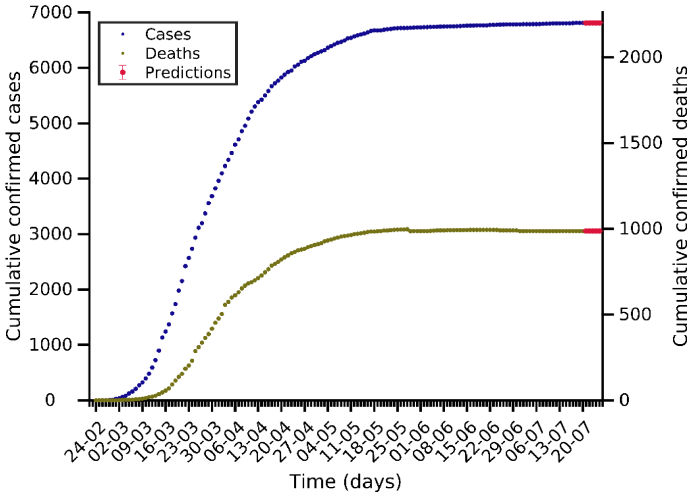


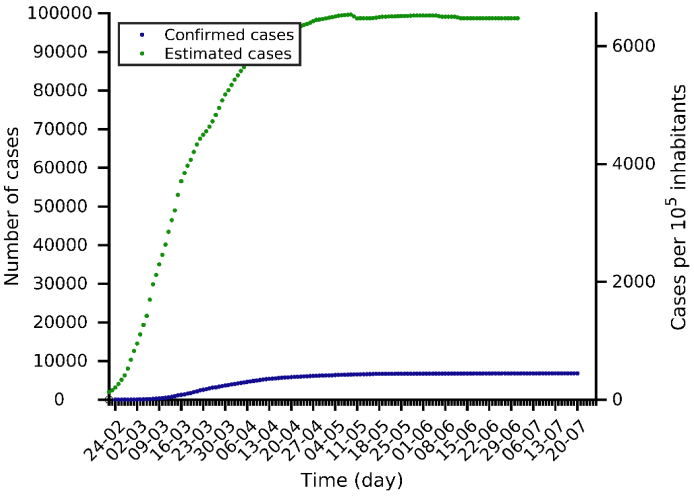


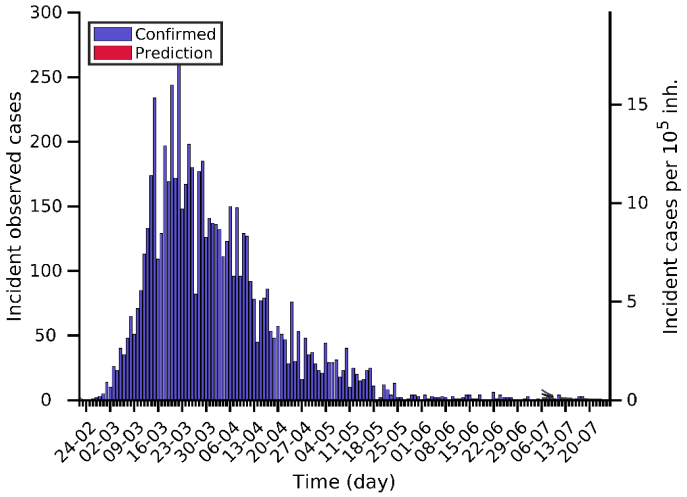


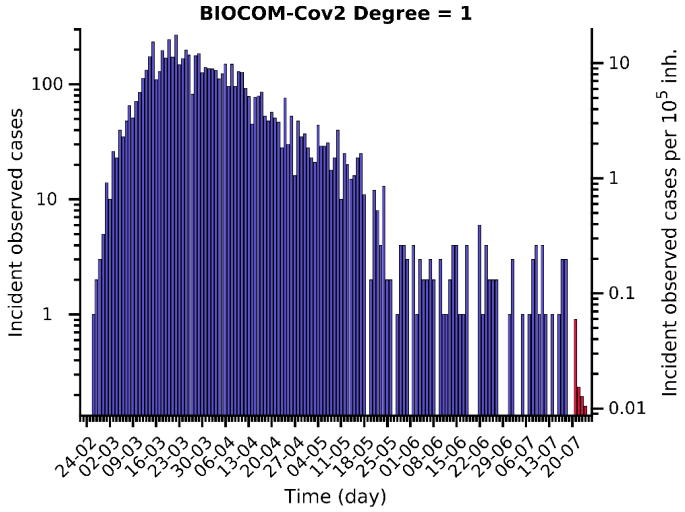


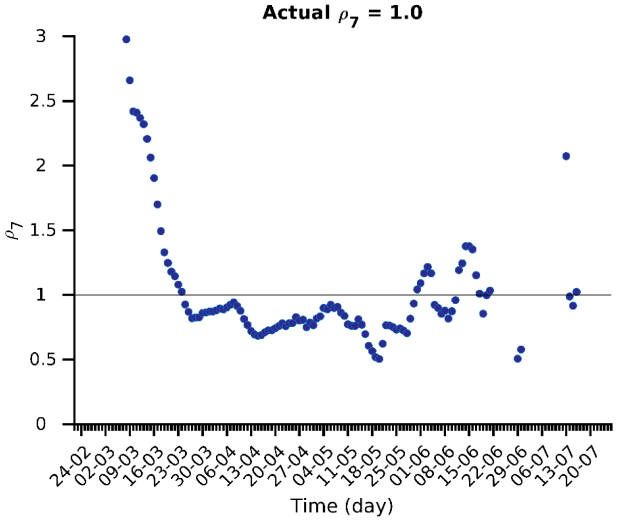
Marche 20-07-2020. Pop: 1.5M. Cumulative incidence: 447/10⁵

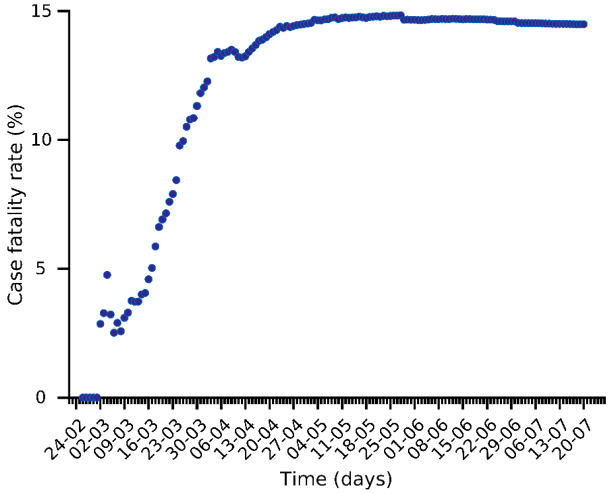


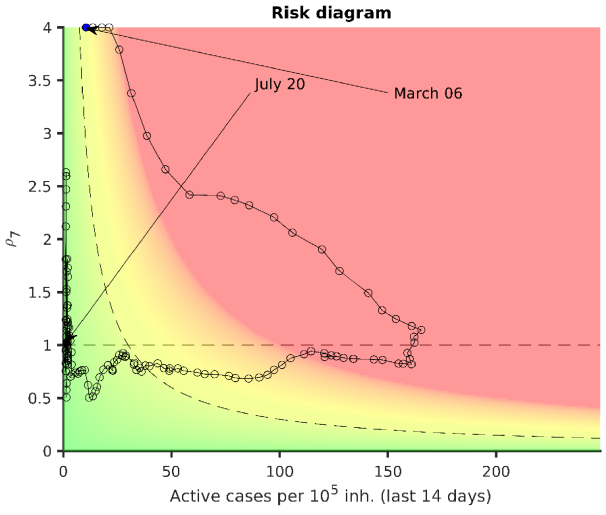


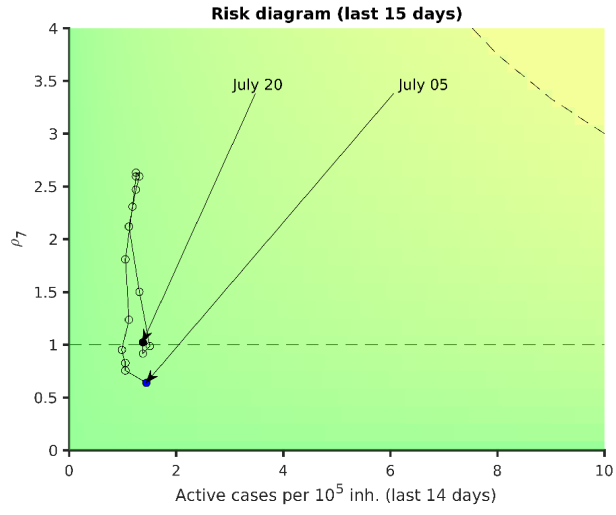




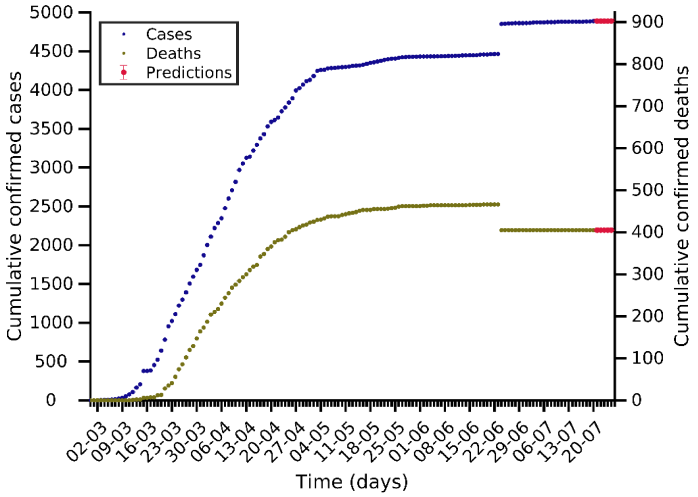


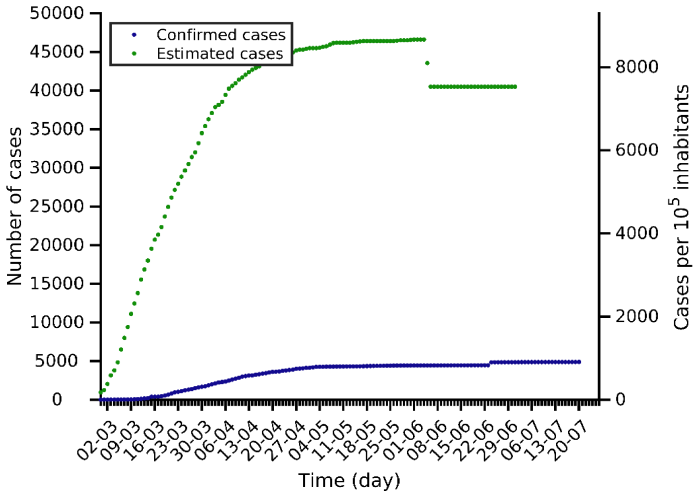


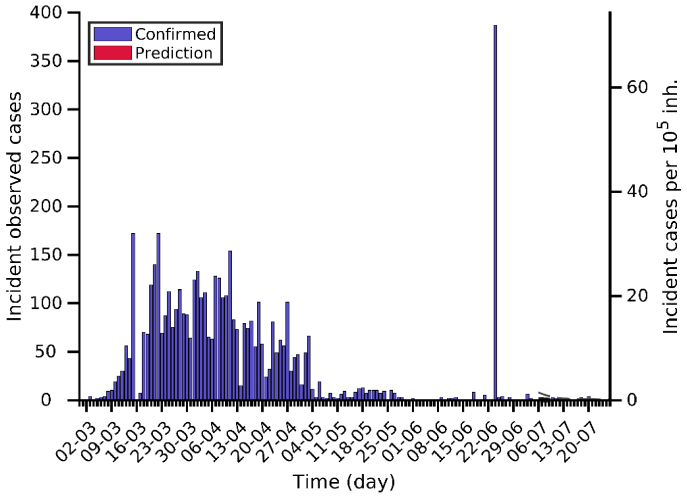


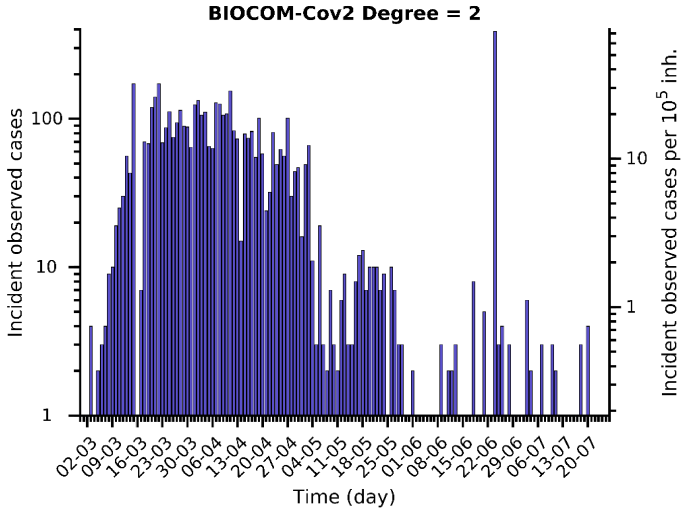


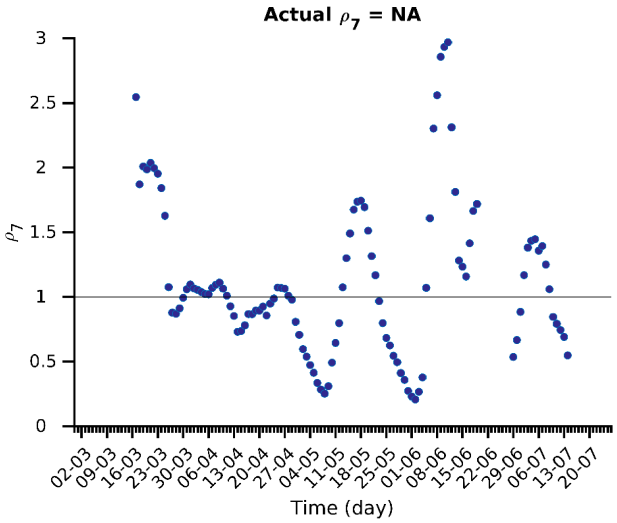
Trento 20-07-2020. Pop: 0.5M. Cumulative incidence: 909/10⁵

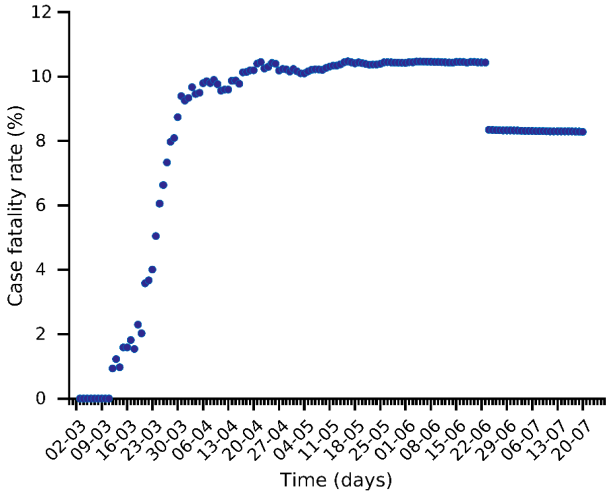


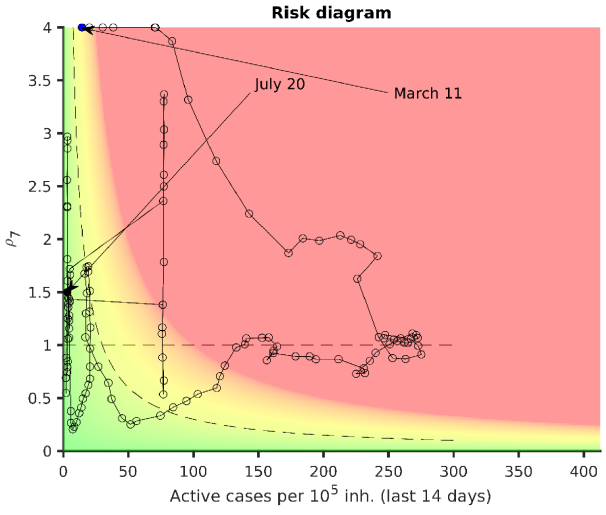


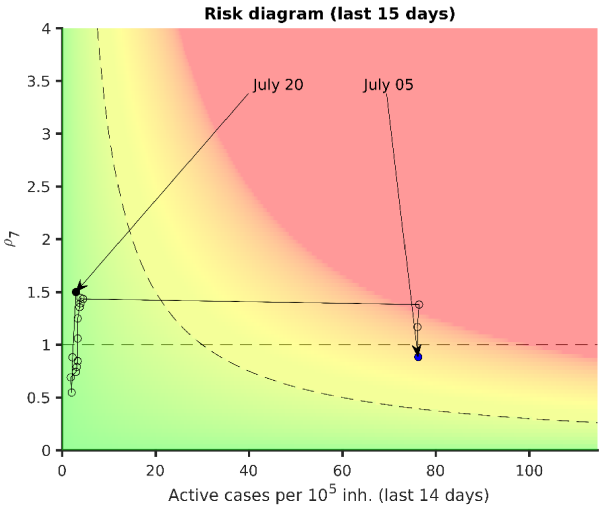




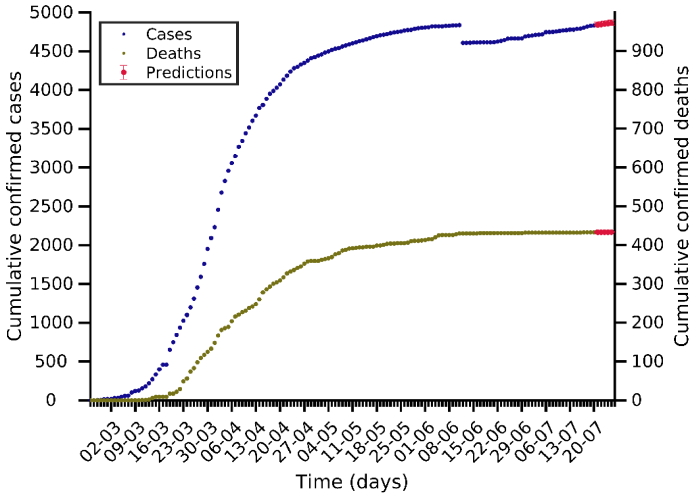


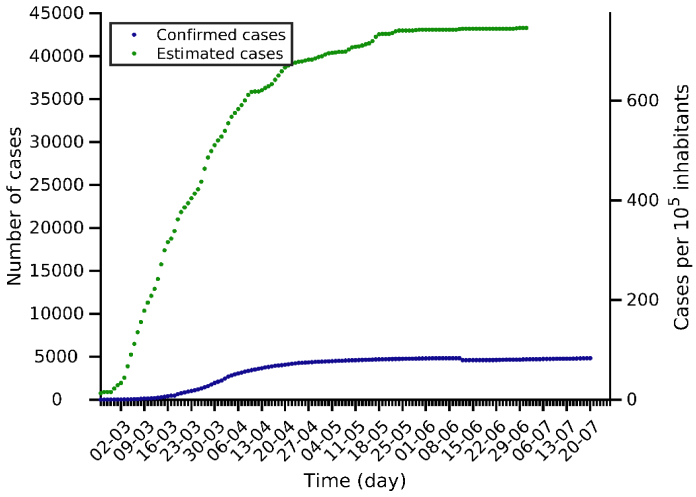


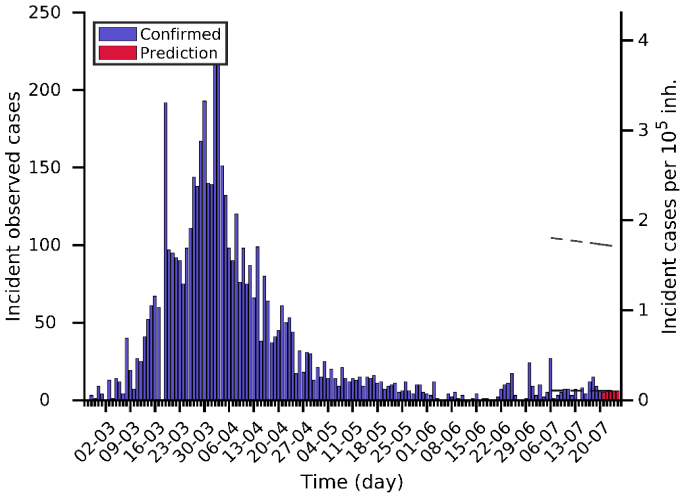


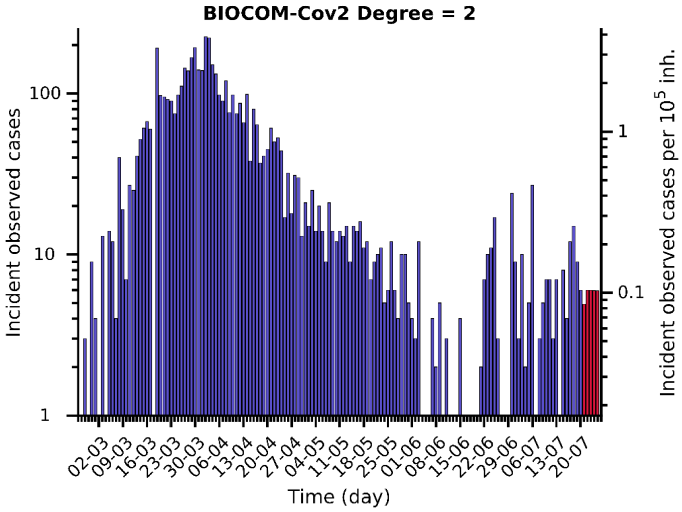


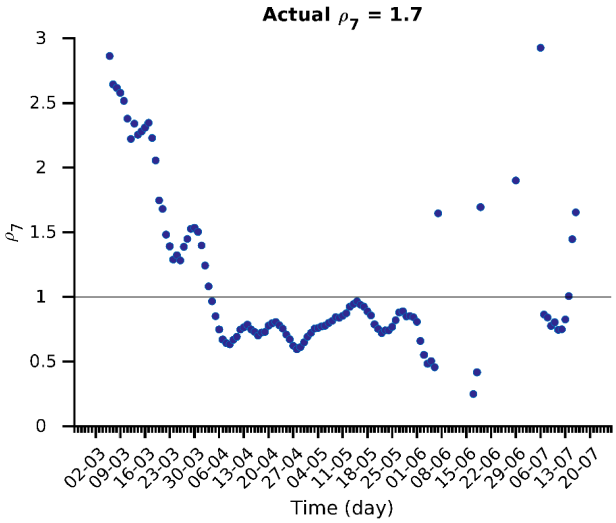
Campania 20-07-2020. Pop: 5.8M. Cumulative incidence: 83/10^5

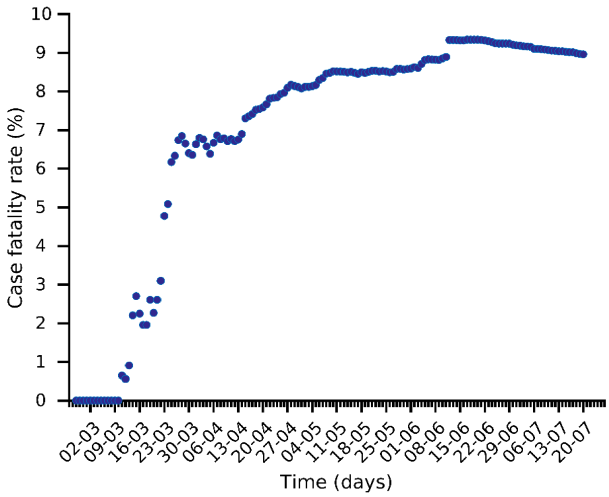


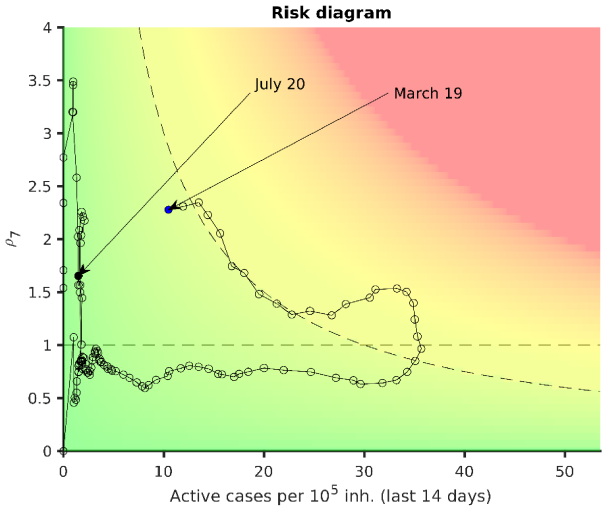


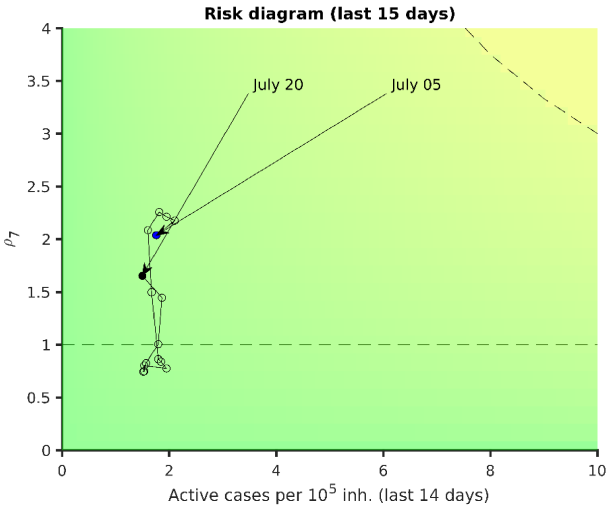




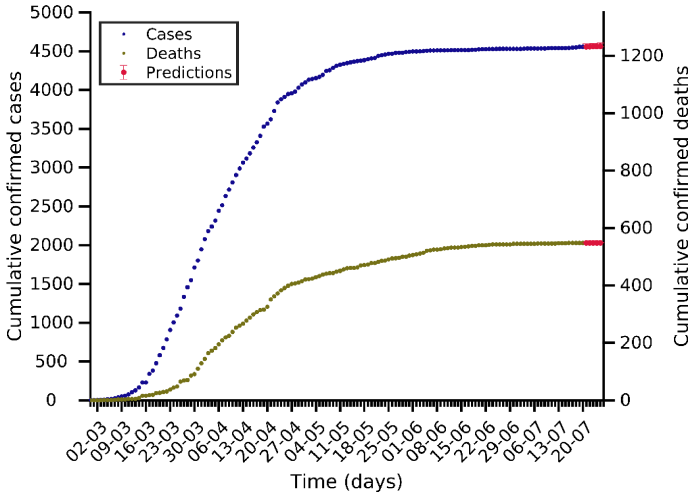


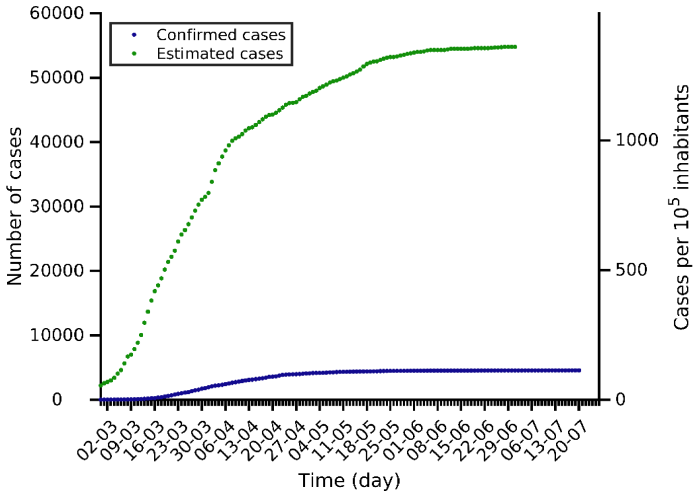


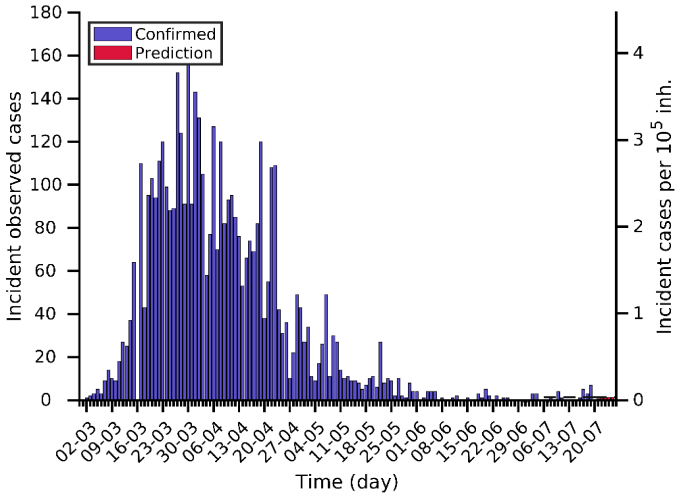


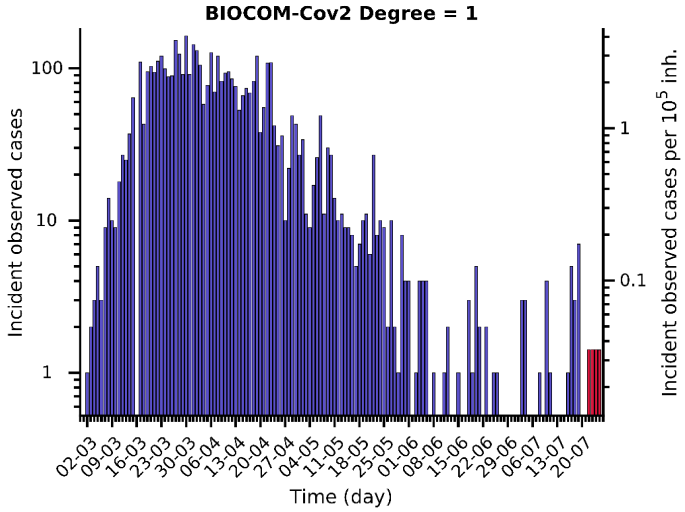


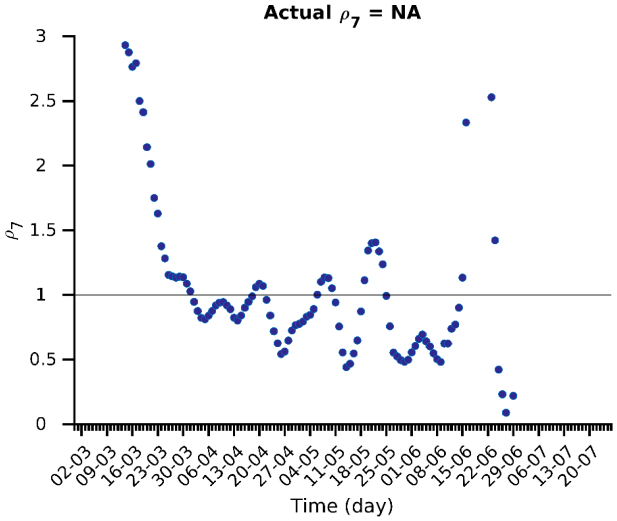
Puglia 20-07-2020. Pop: 4.0M. Cumulative incidence: 113/10⁵

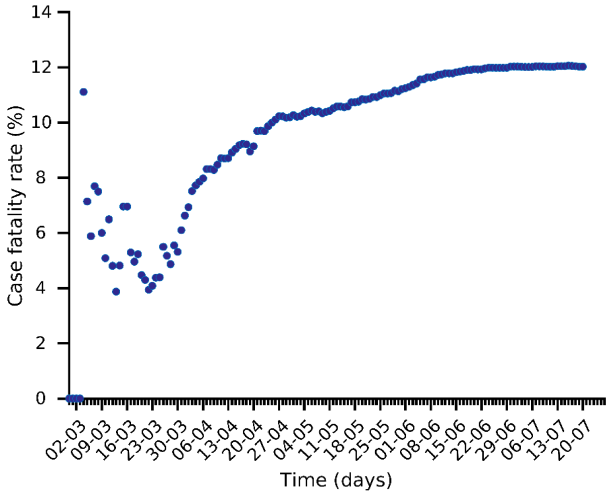


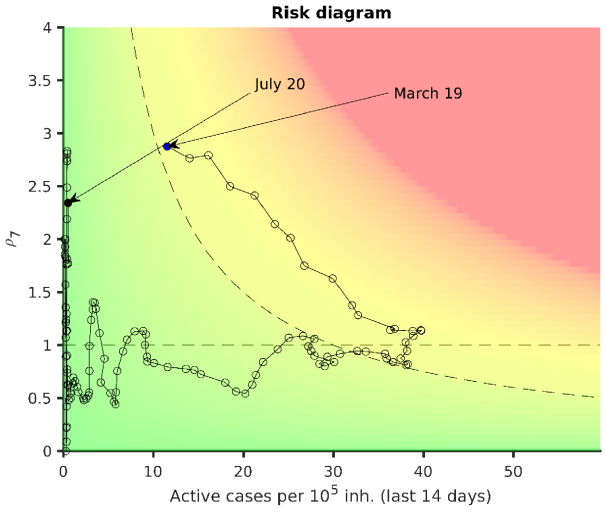


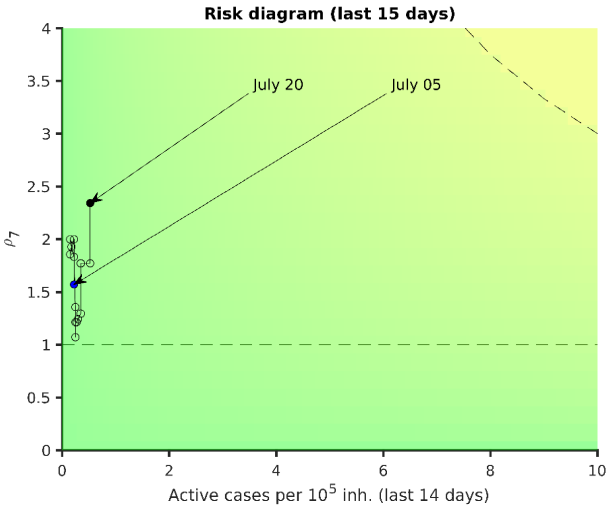




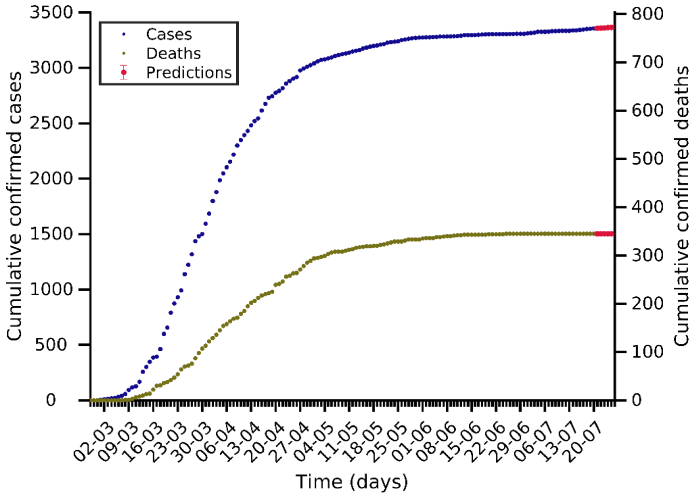


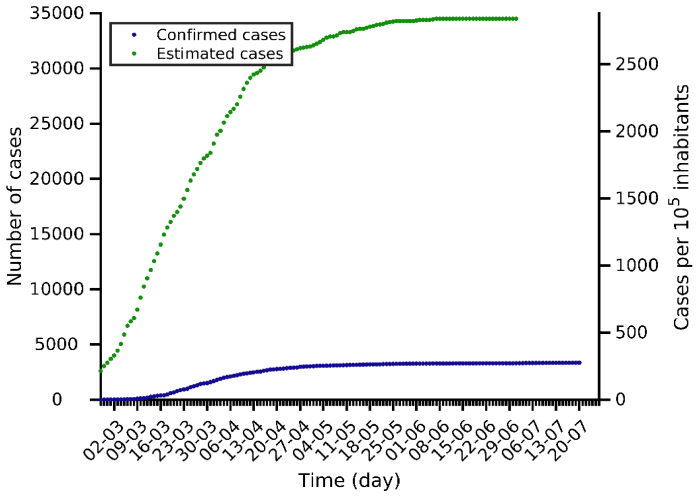


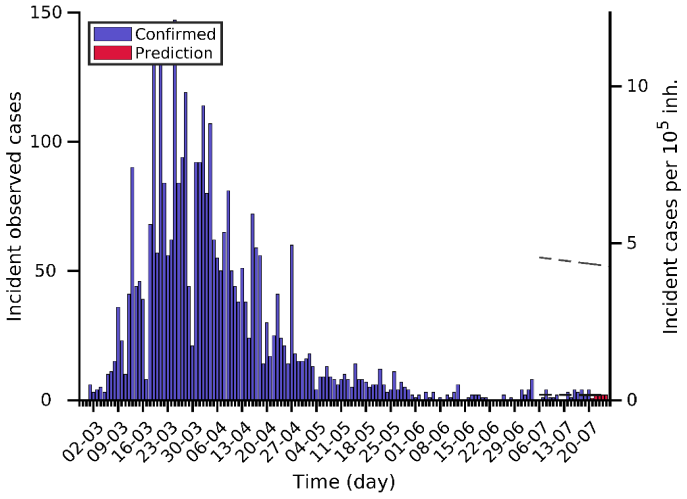


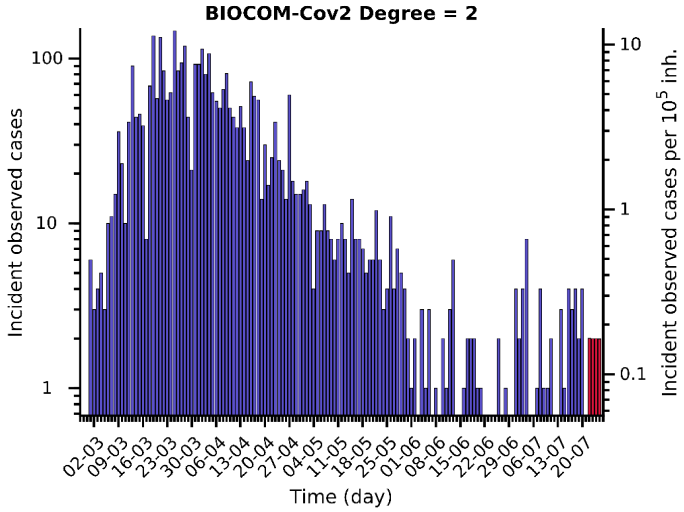


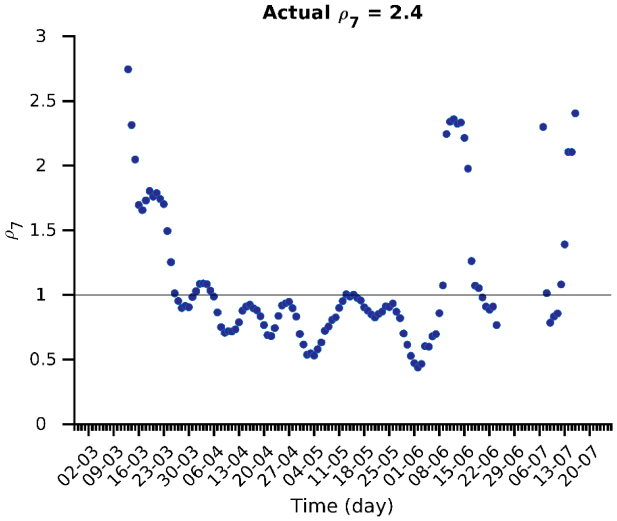
Friuli Venezia Giulia 20-07-2020. Pop: 1.2M. Cumulative incidence: 276/10⁵

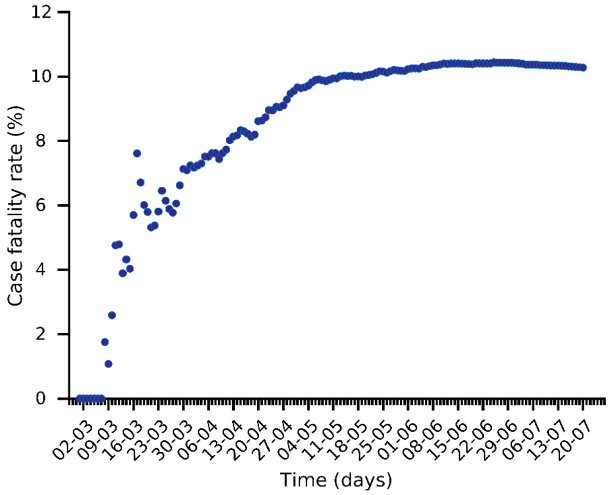


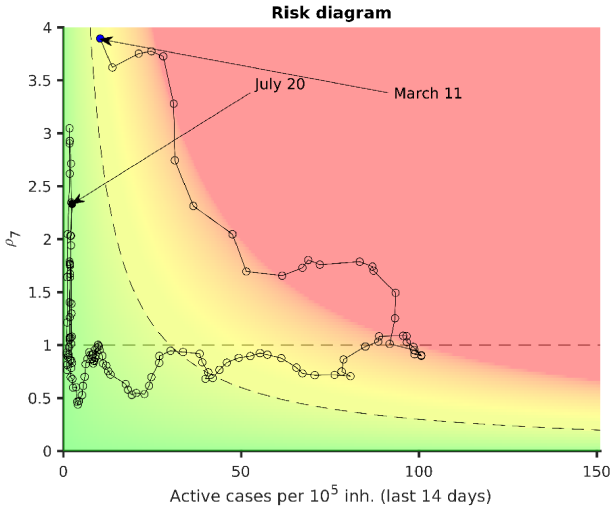


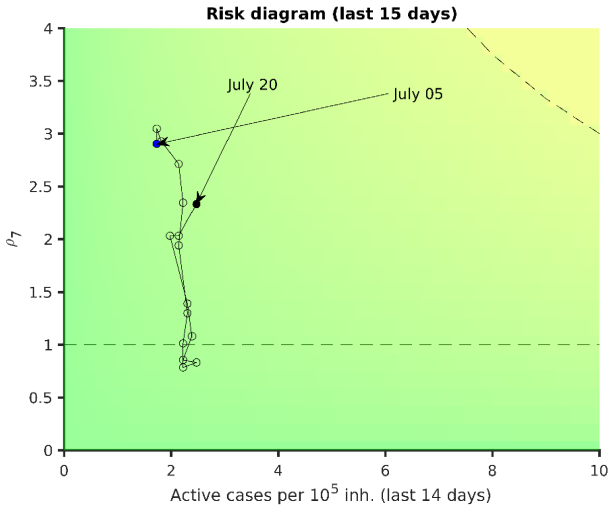




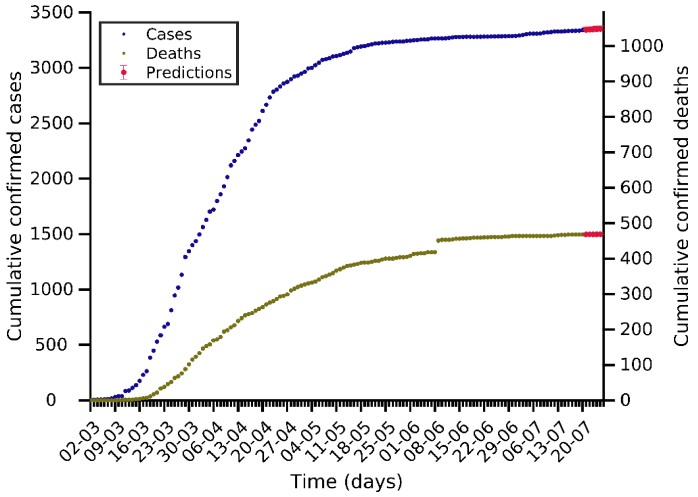


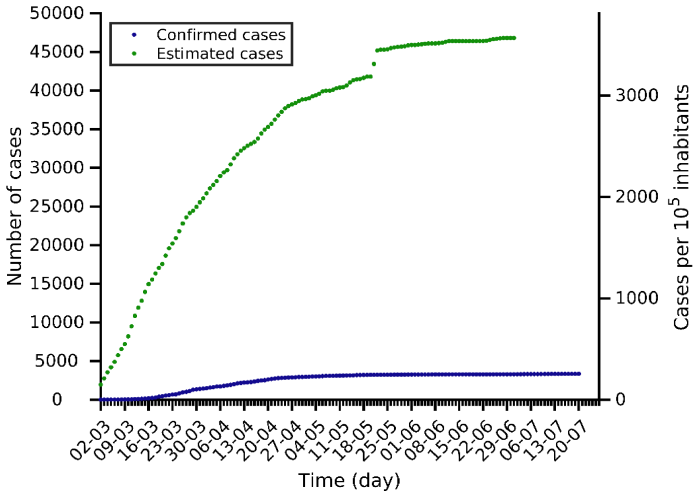


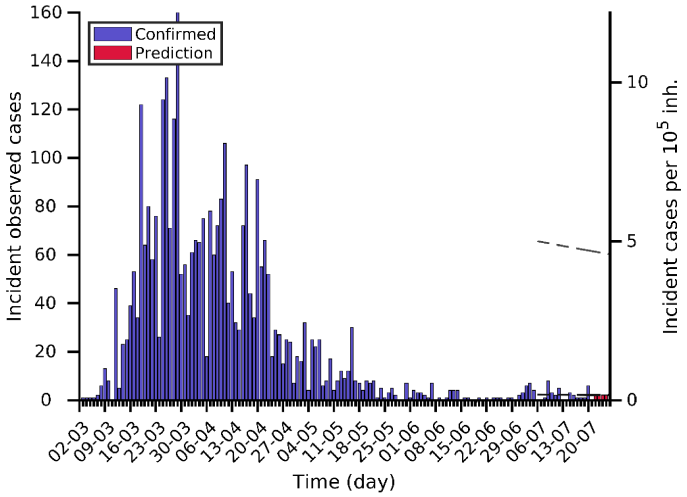


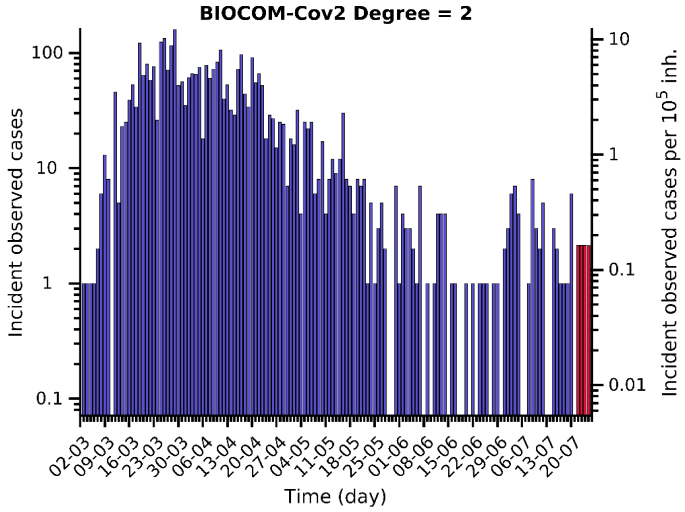


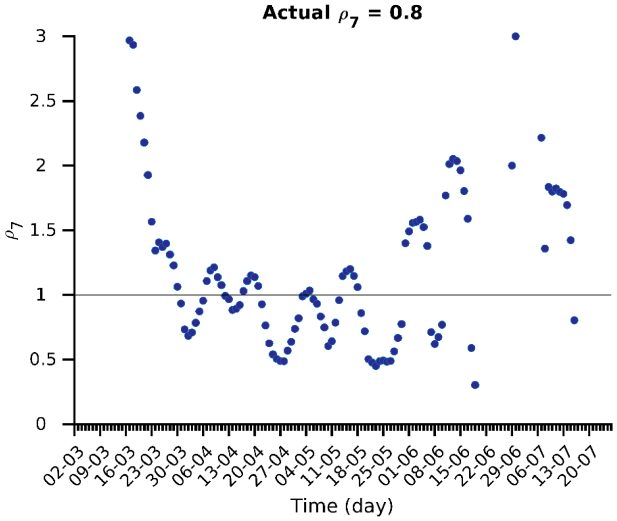
Abruzzo 20-07-2020. Pop: 1.3M. Cumulative incidence: 255/10⁵

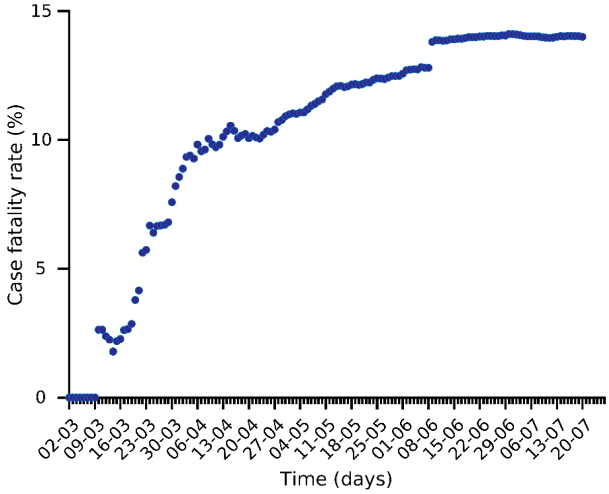


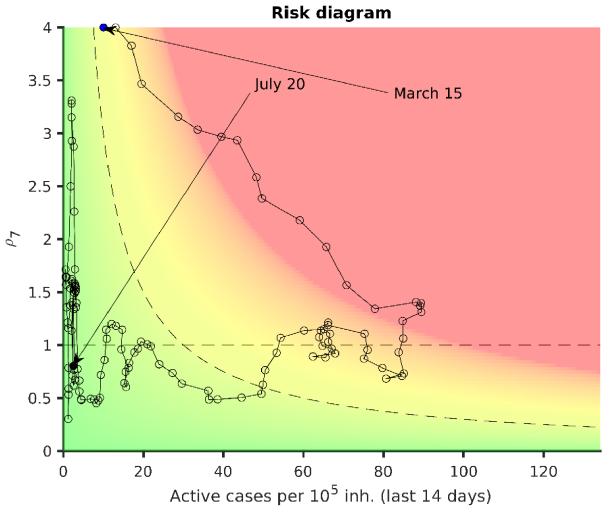


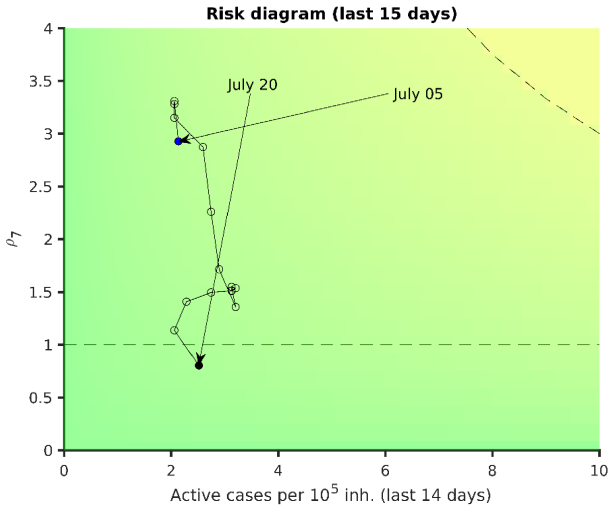




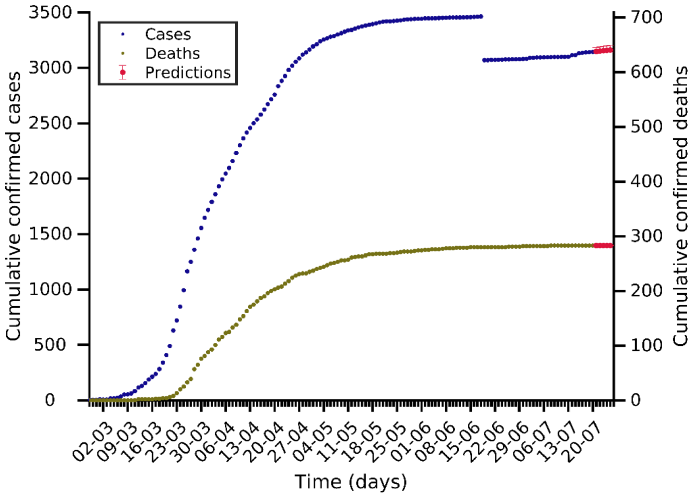


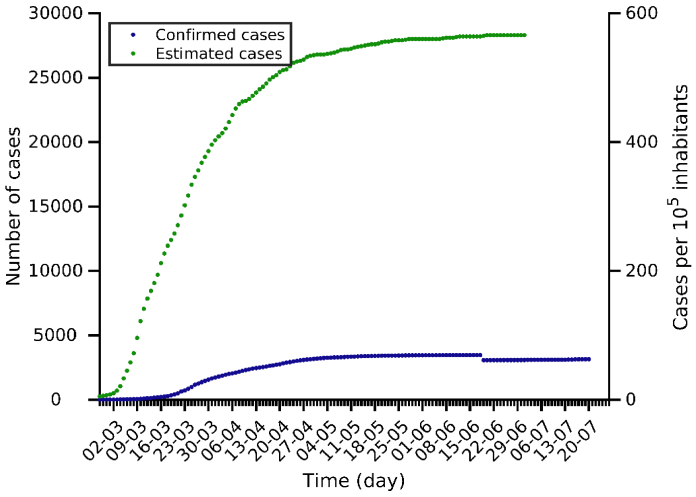


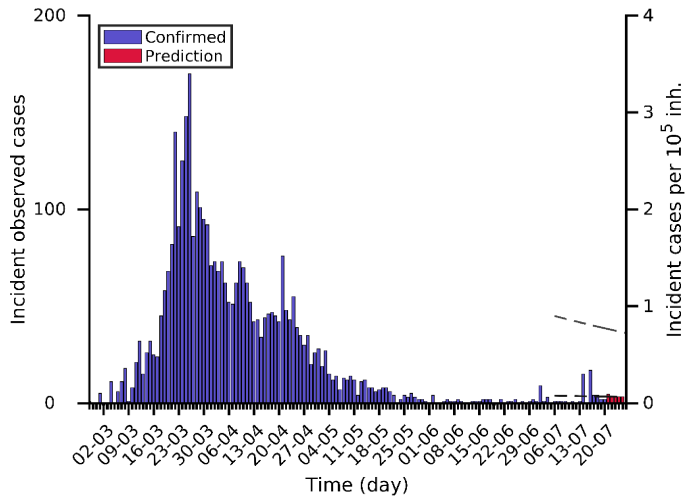


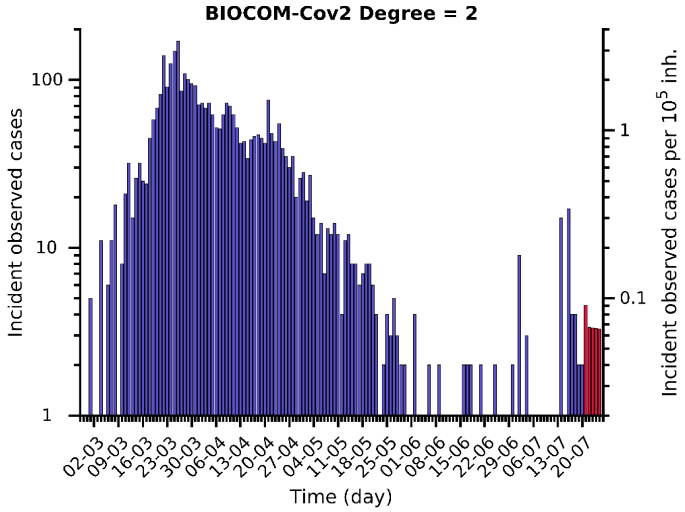


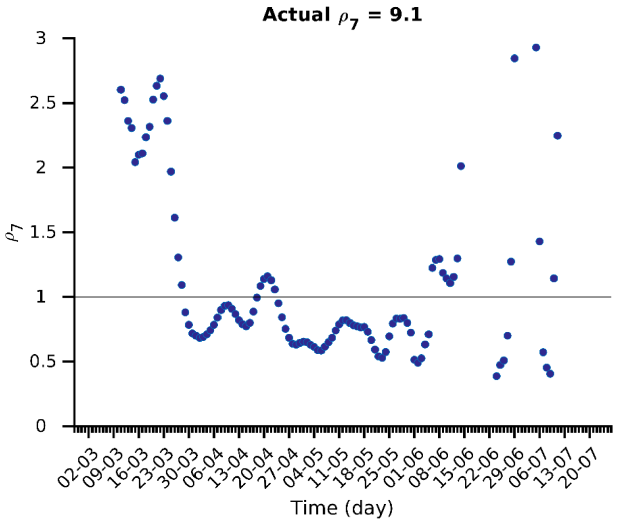
Sicilia 20-07-2020. Pop: 5.0M. Cumulative incidence: 63/10⁵

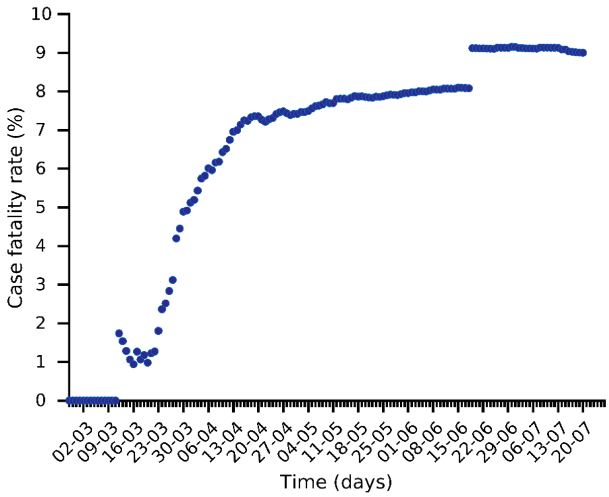


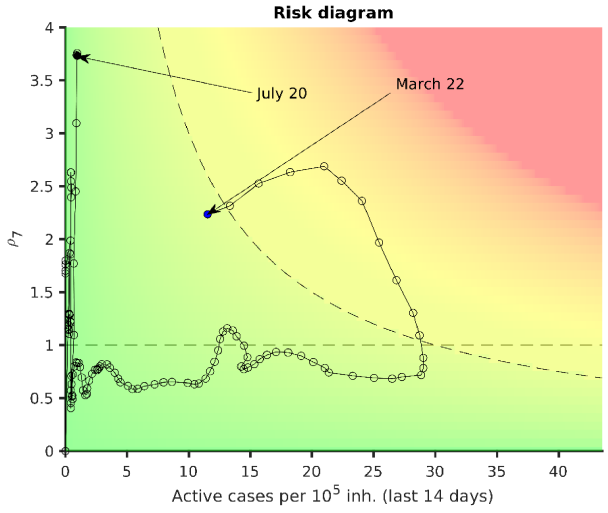


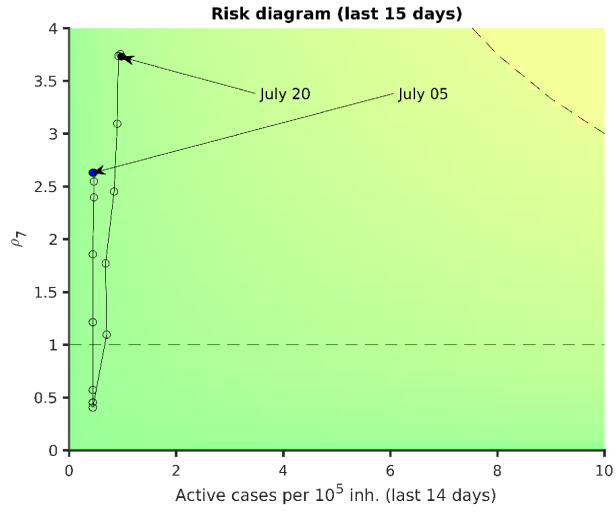




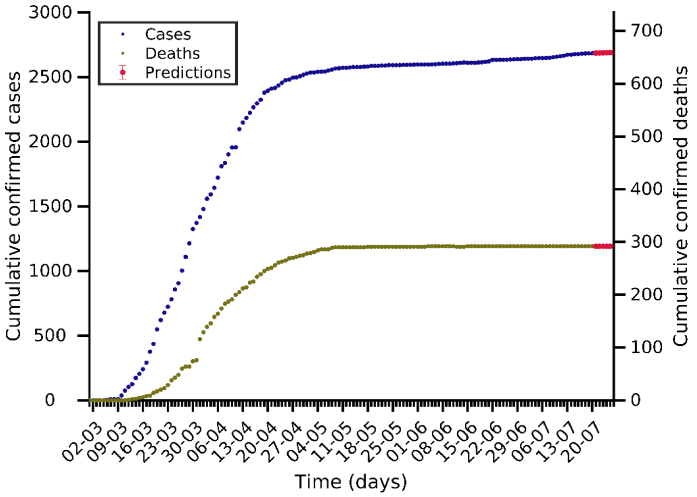


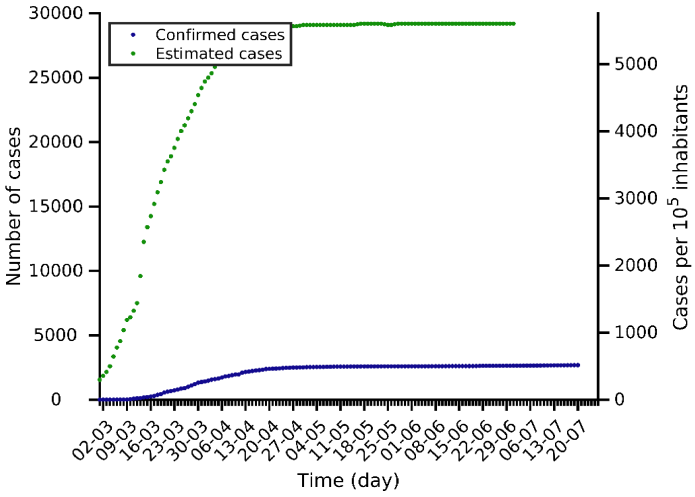


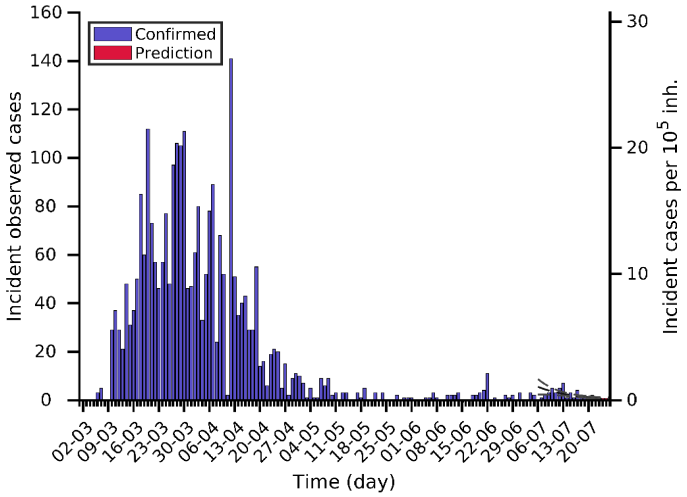


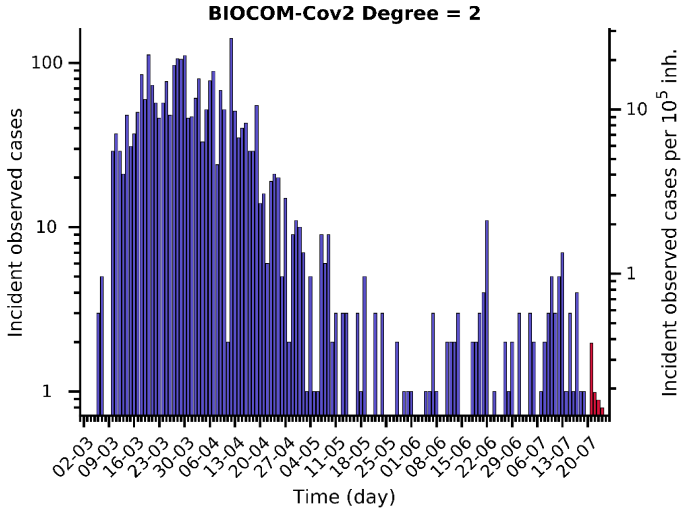


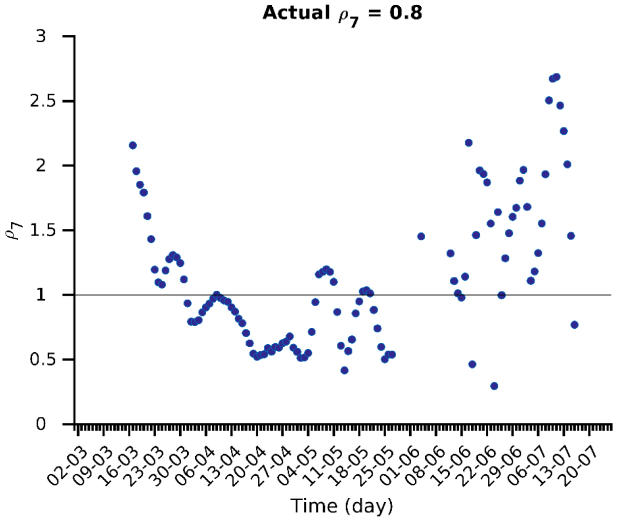
Bolzano 20-07-2020. Pop: 0.5M. Cumulative incidence: 515/10⁵

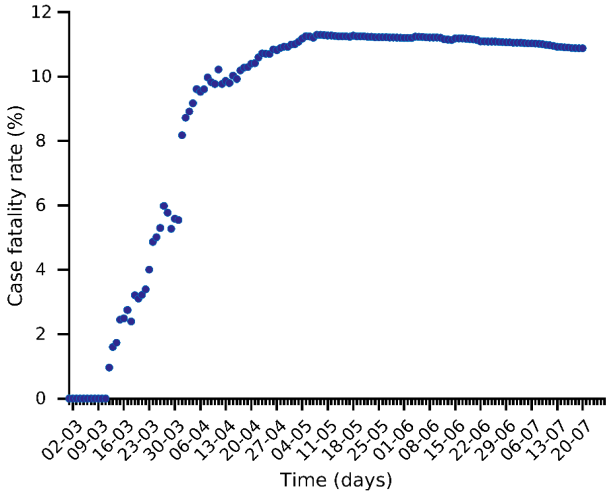


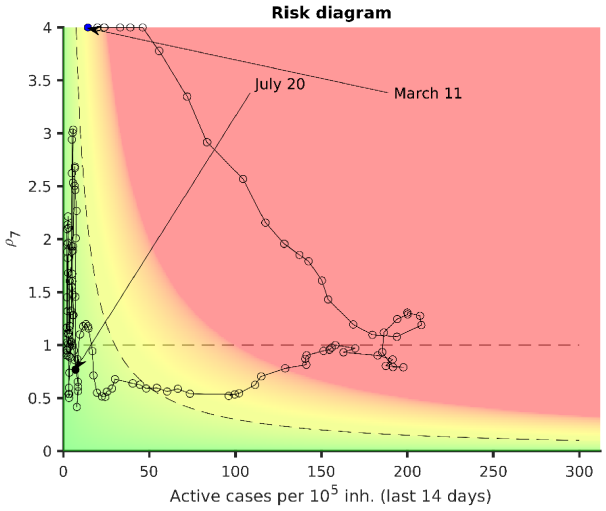


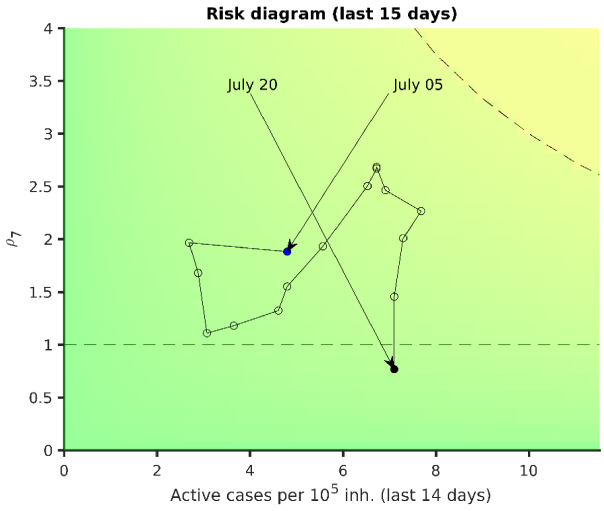




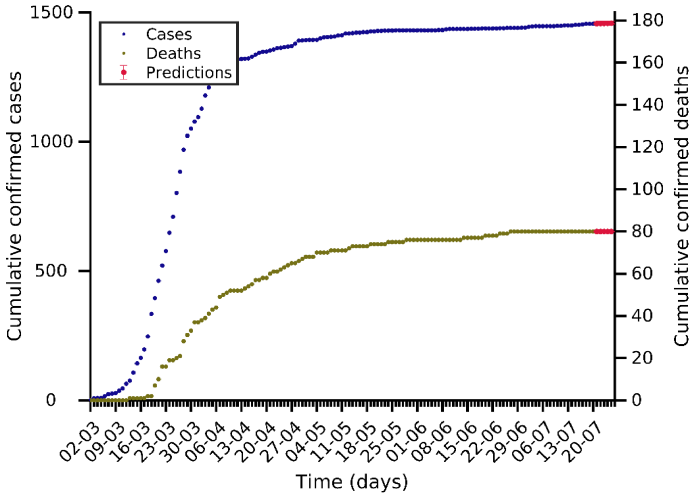


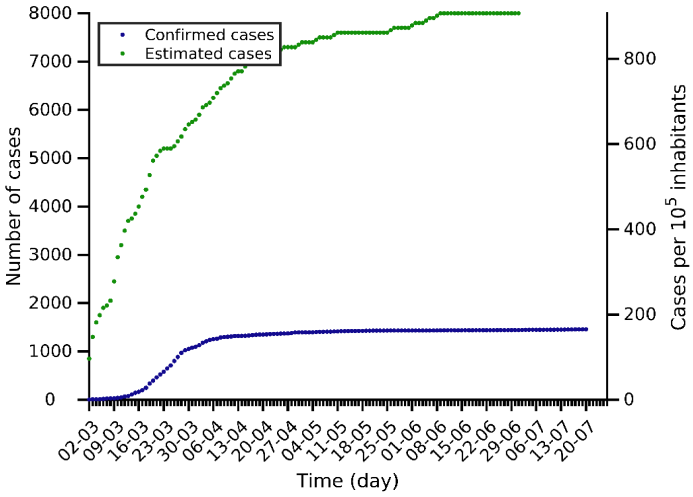


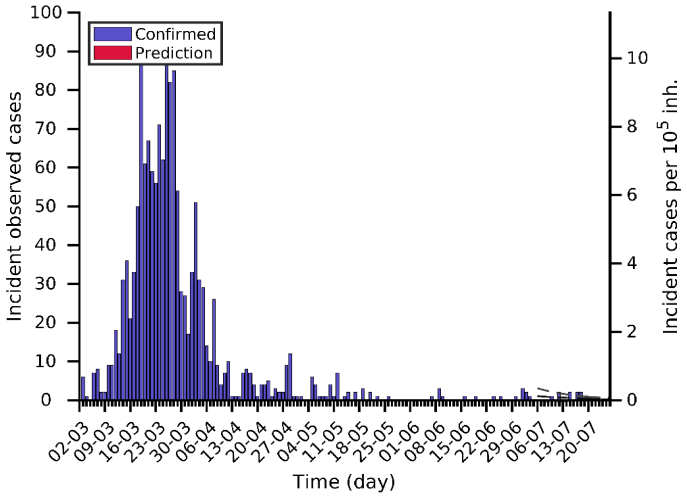


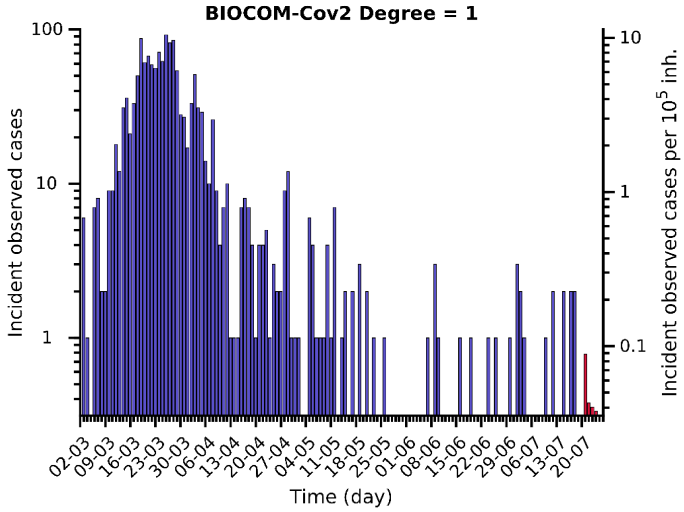


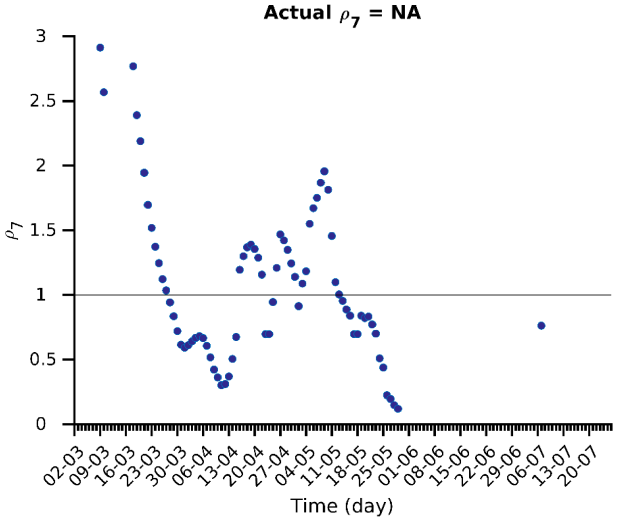
Umbria 20-07-2020. Pop: 0.9M. Cumulative incidence: 165/10⁵

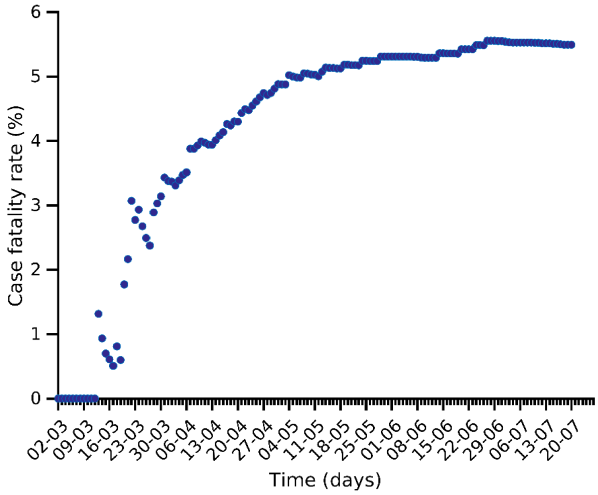


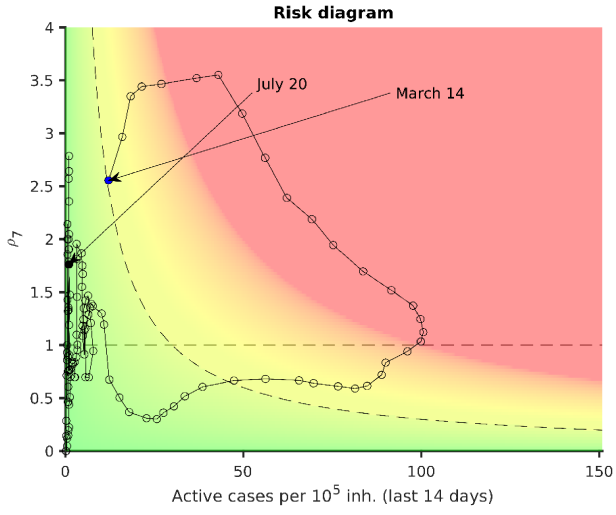


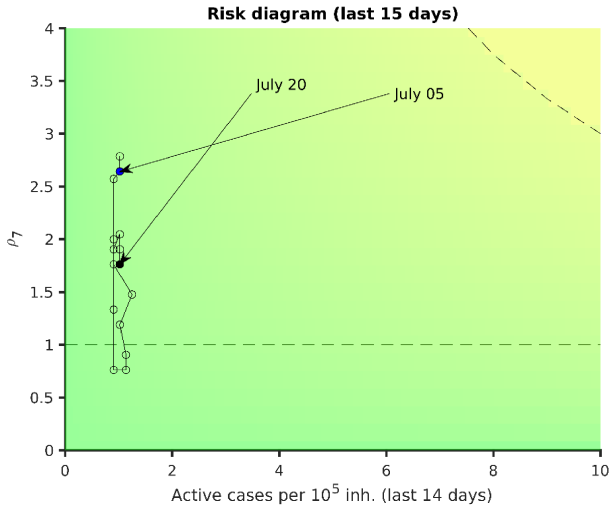




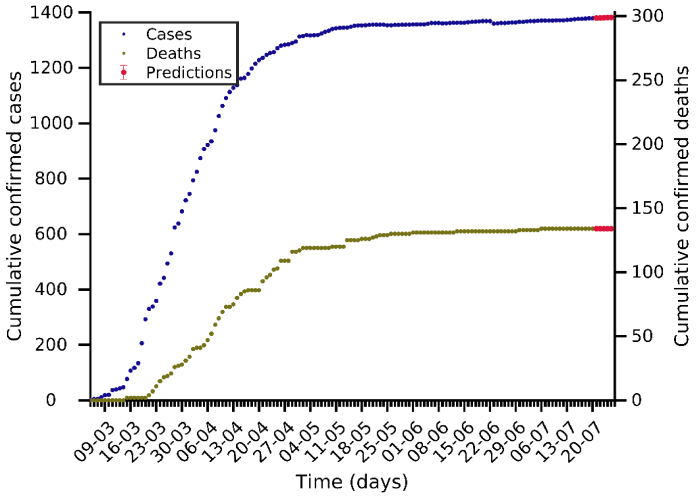


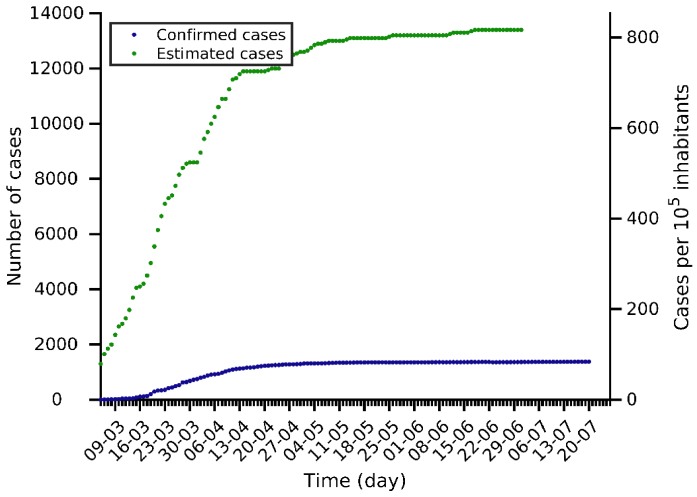


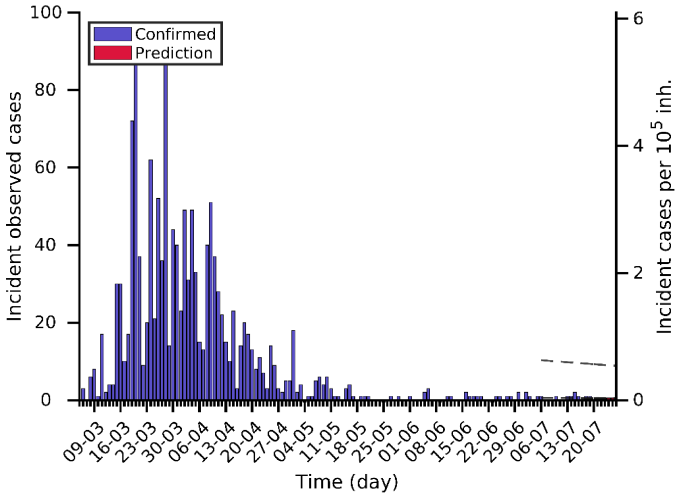


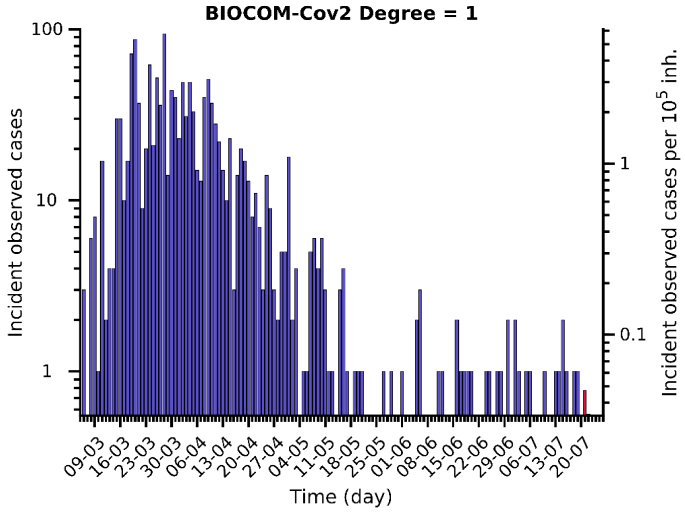


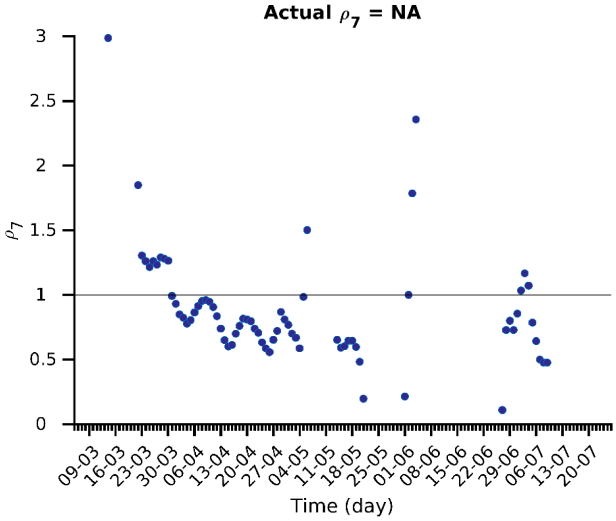
Sardegna 20-07-2020. Pop: 1.6M. Cumulative incidence: 84/10⁵

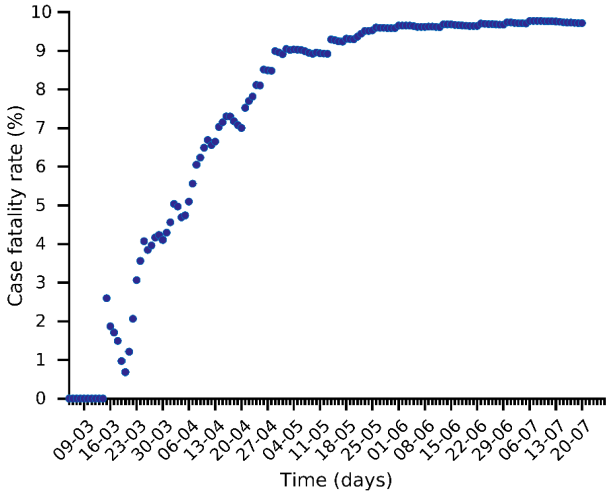


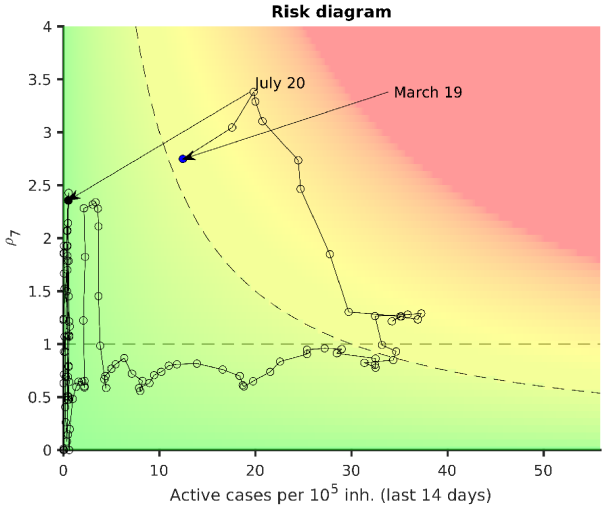


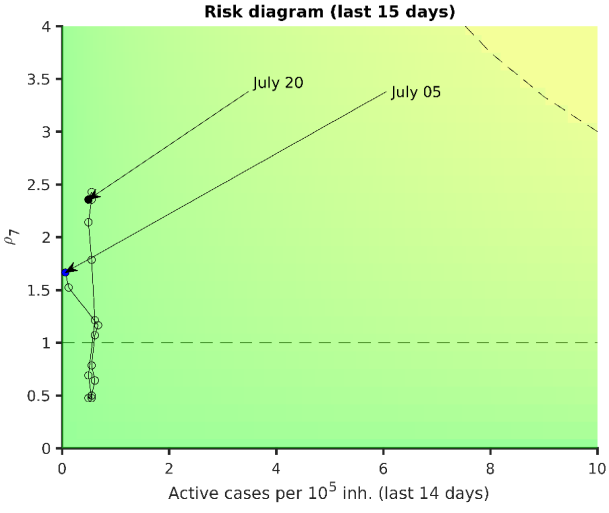




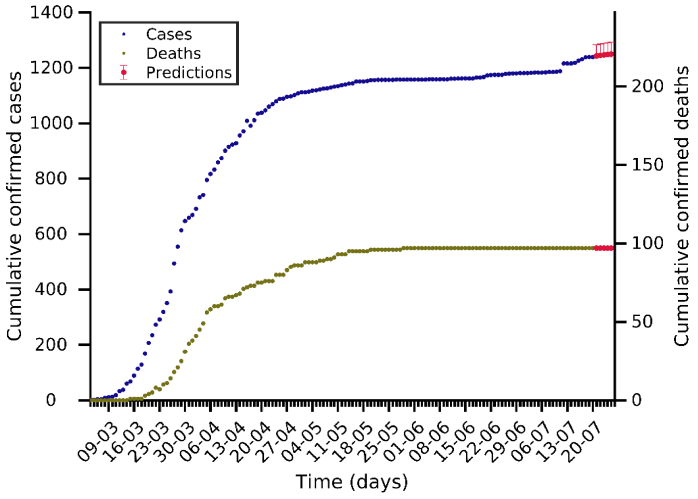


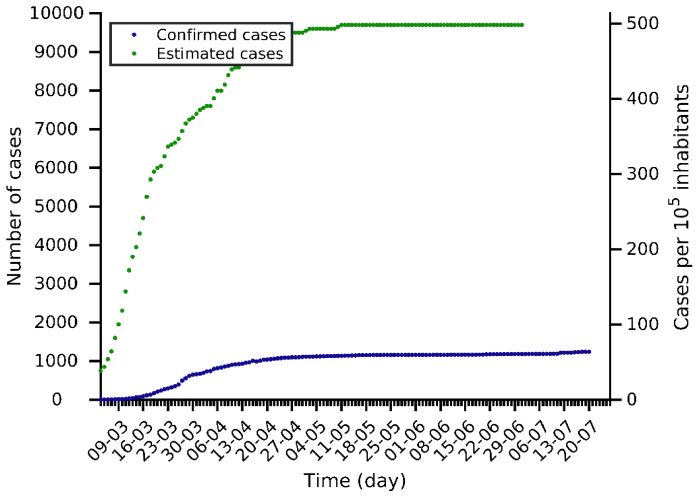


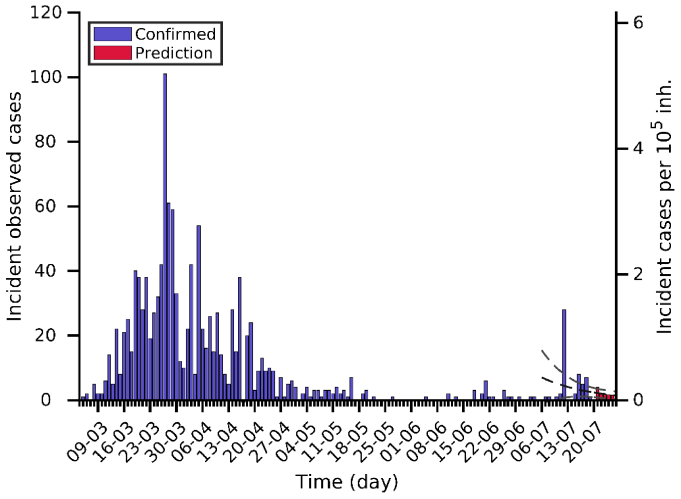


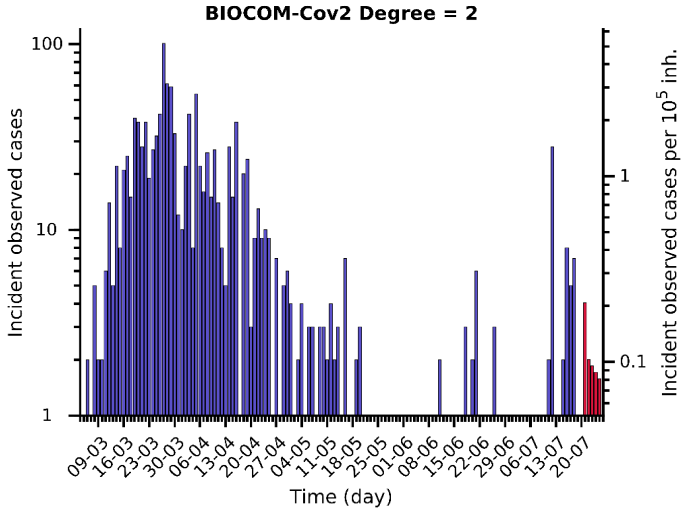


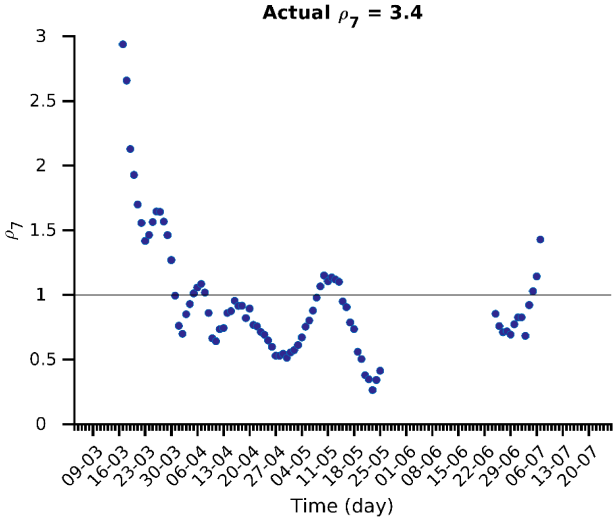
Calabria 20-07-2020. Pop: 1.9M. Cumulative incidence: 64/10^5

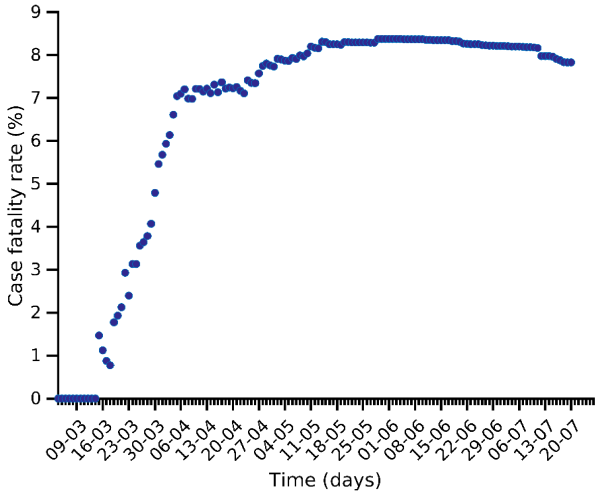


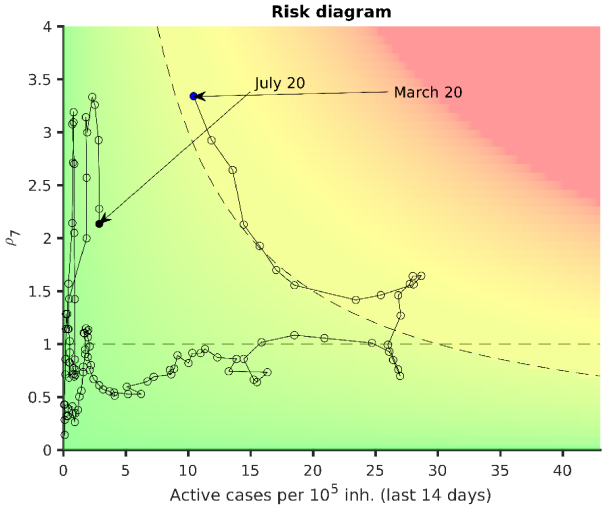


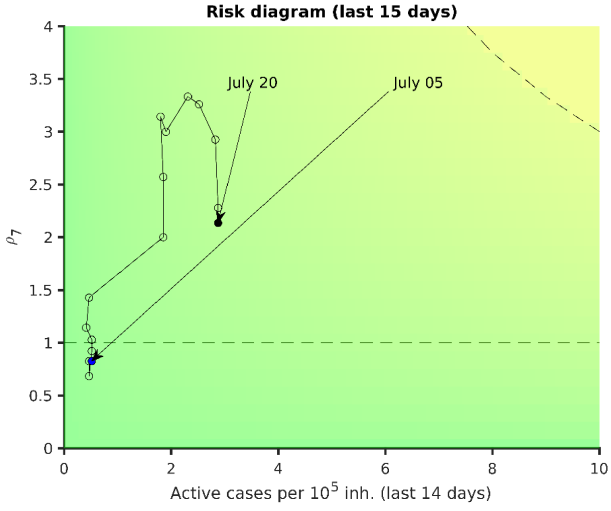




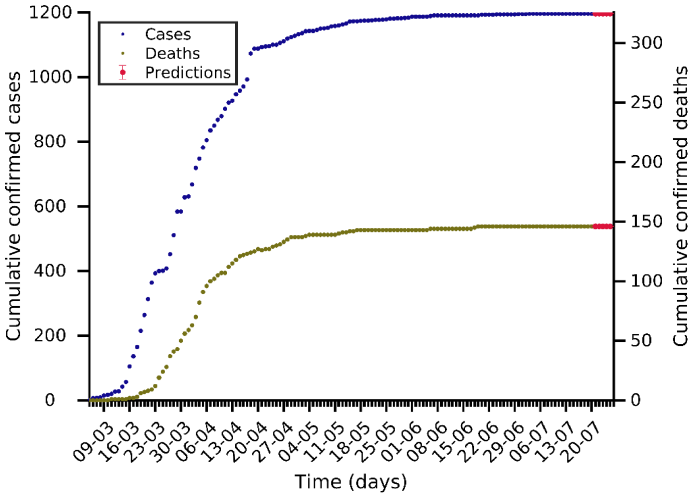


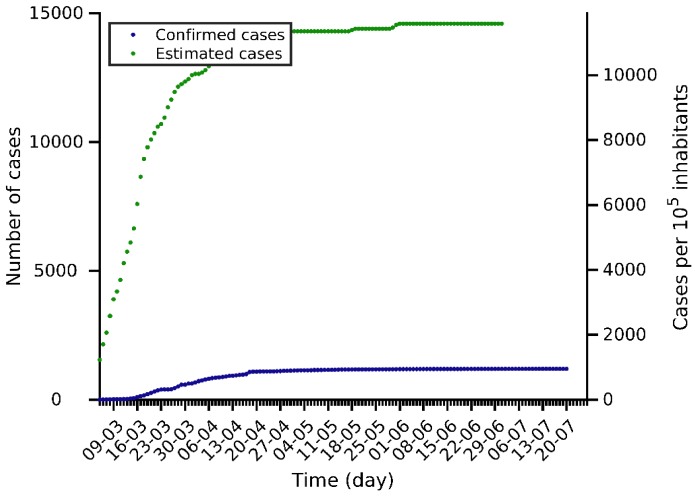


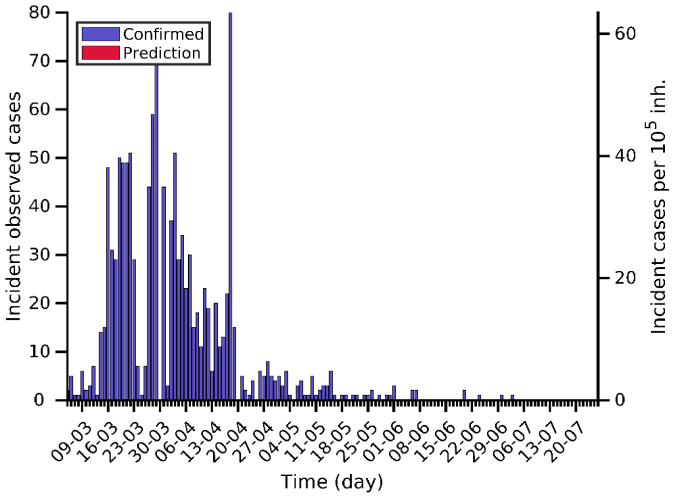


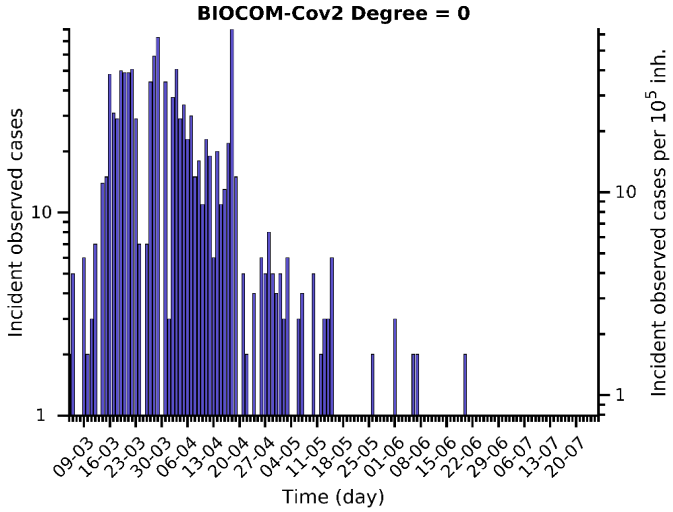


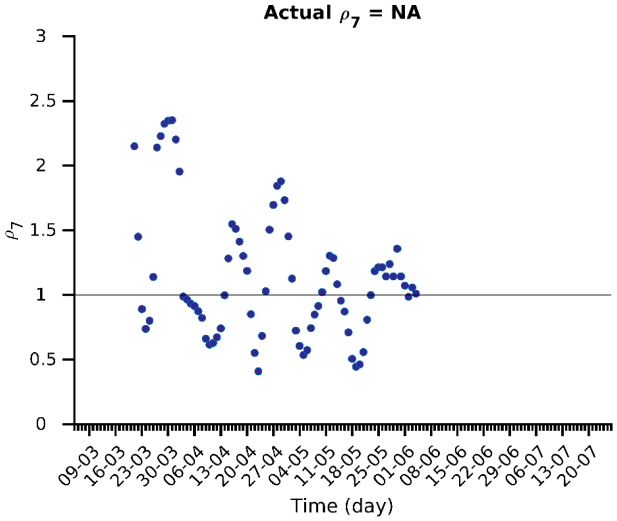
Valle dAosta 20-07-2020. Pop: 0.1M. Cumulative incidence: 949/10⁵

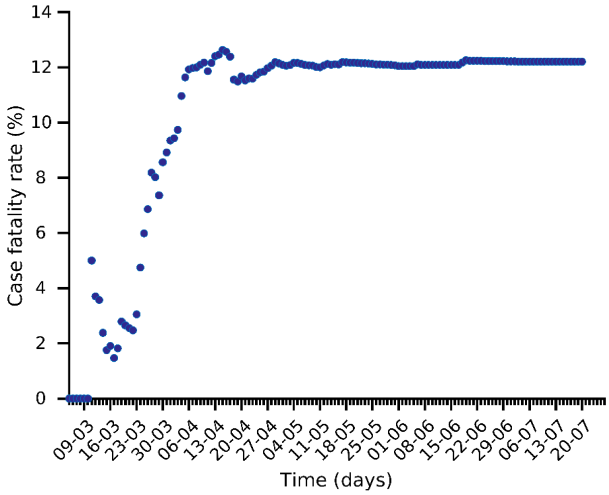


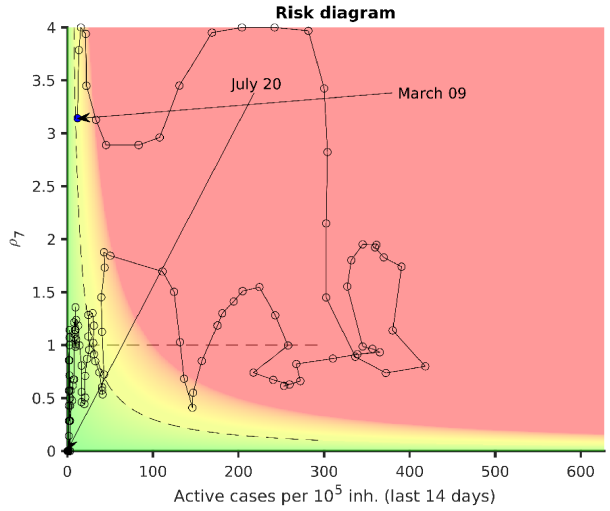


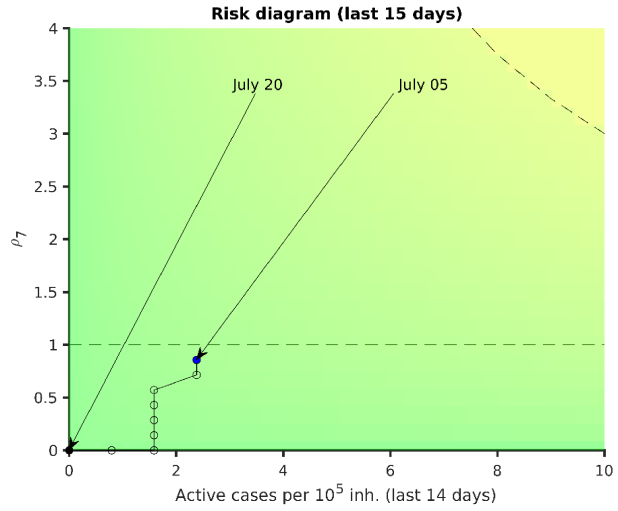




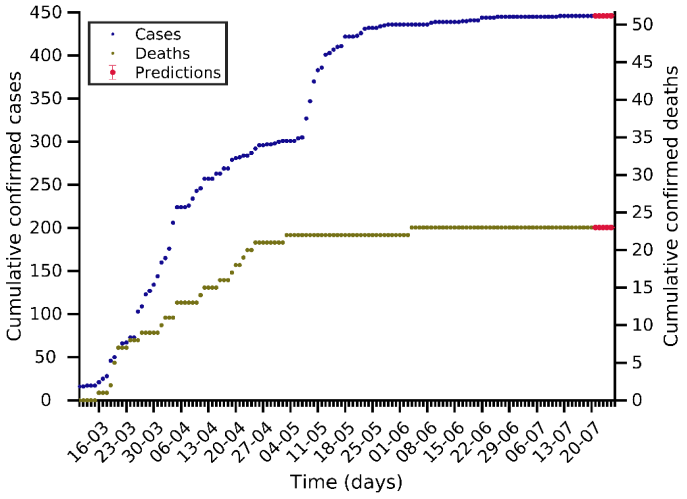


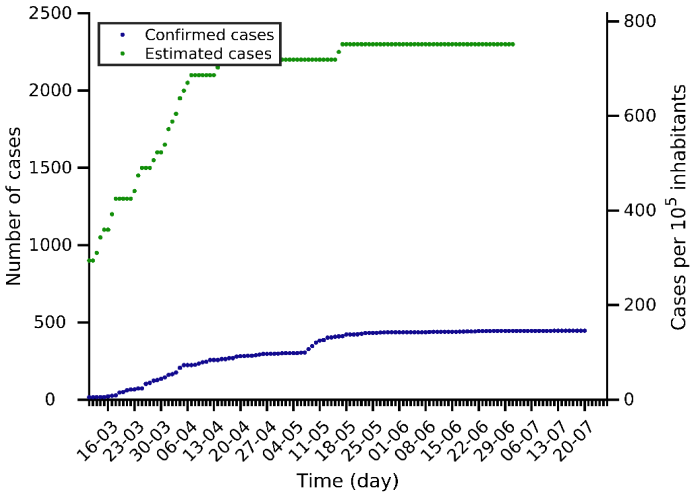


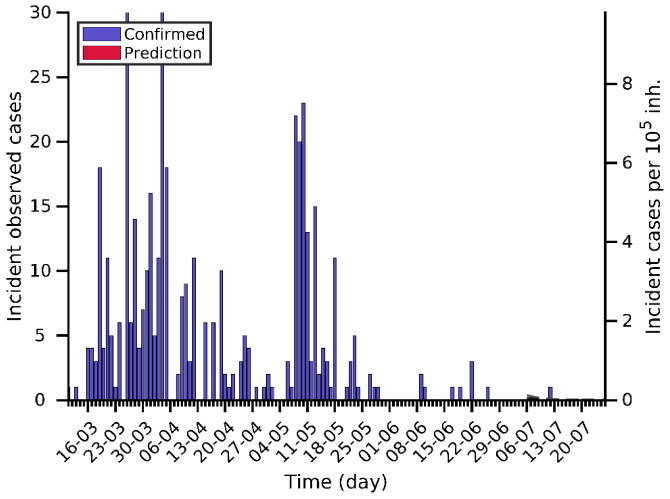


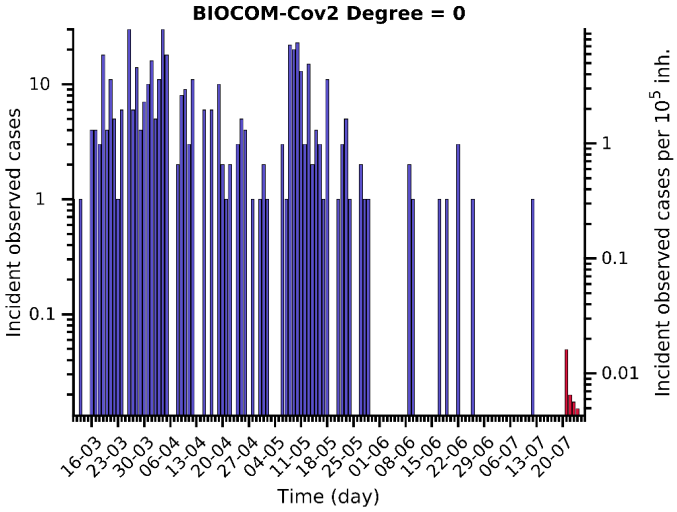


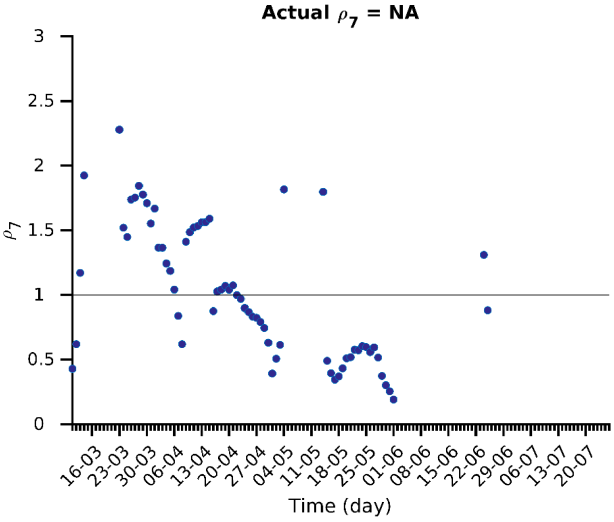
Molise 20-07-2020. Pop: 0.3M. Cumulative incidence: 146/10⁵

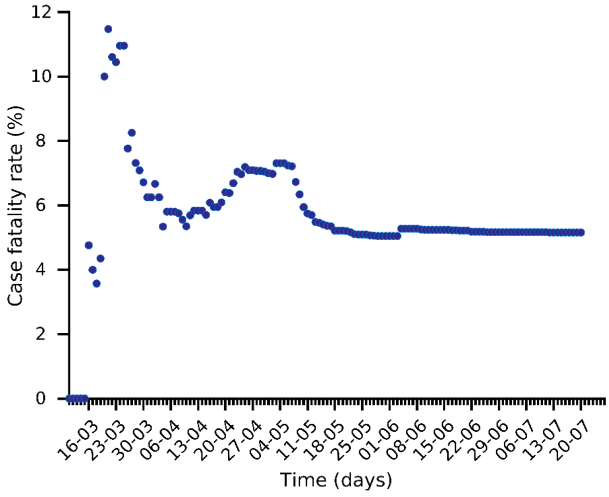


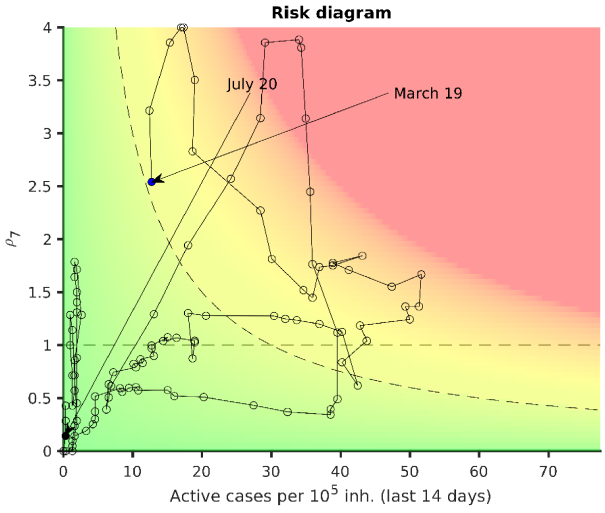


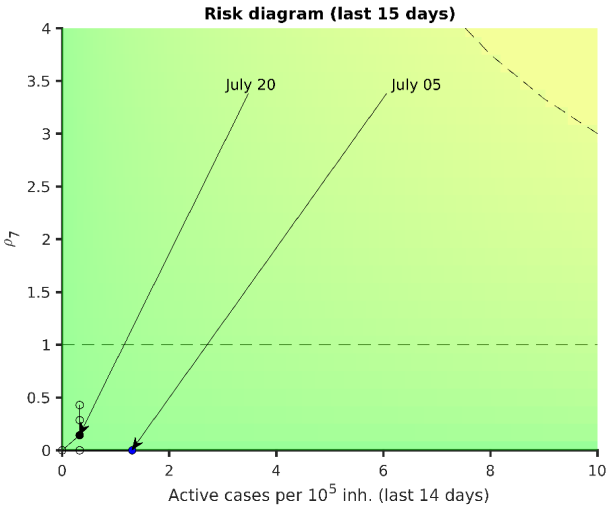




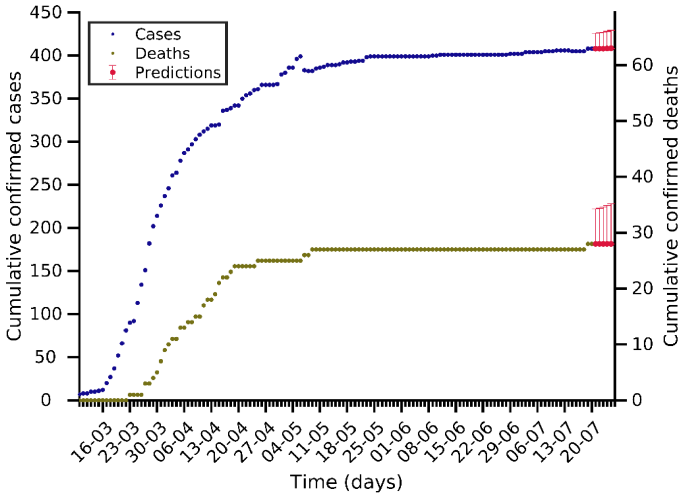


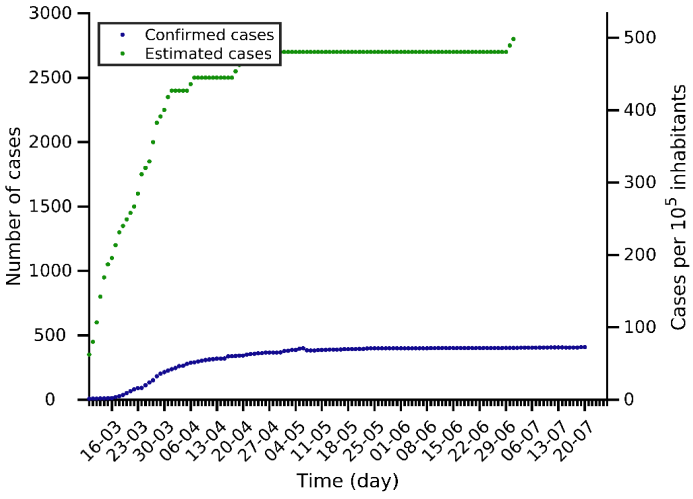


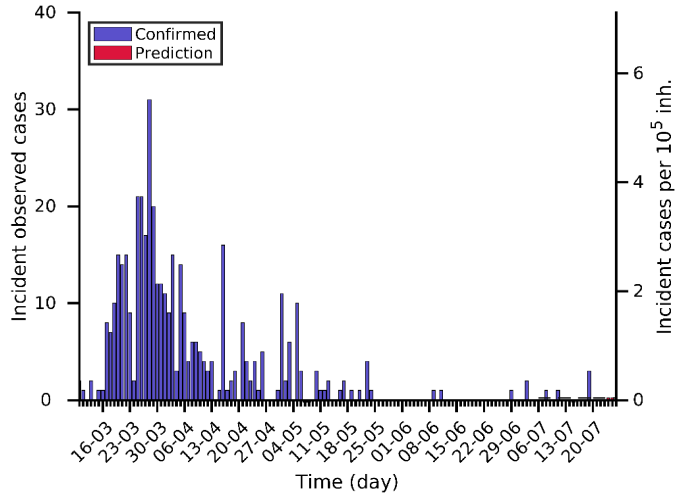


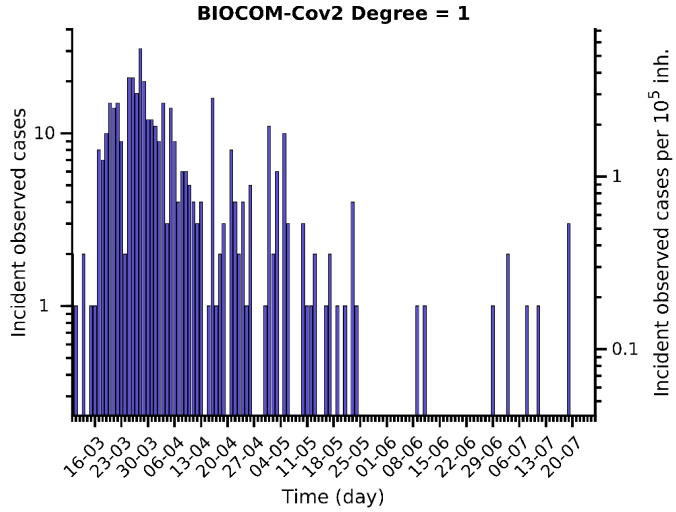


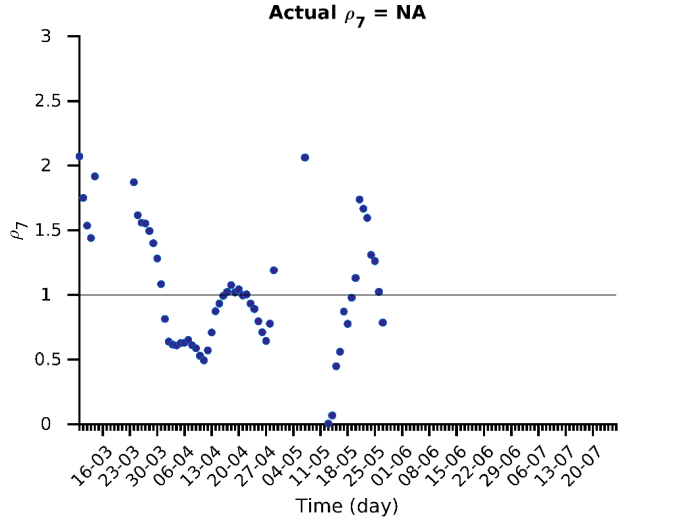
Basilicata 20-07-2020. Pop: 0.6M. Cumulative incidence: 73/10⁵

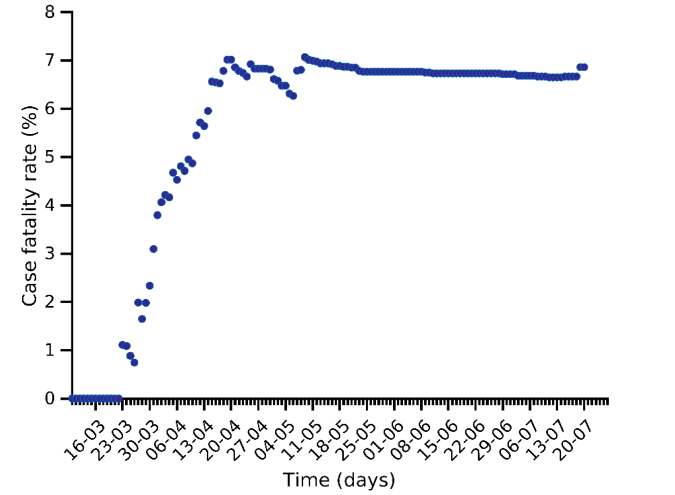


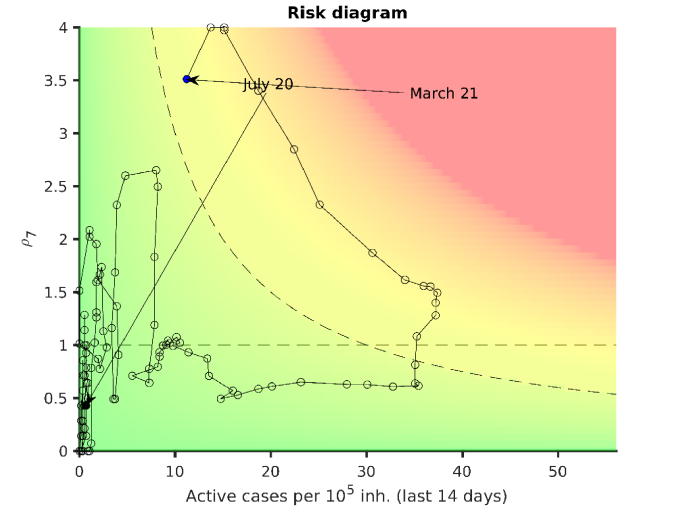


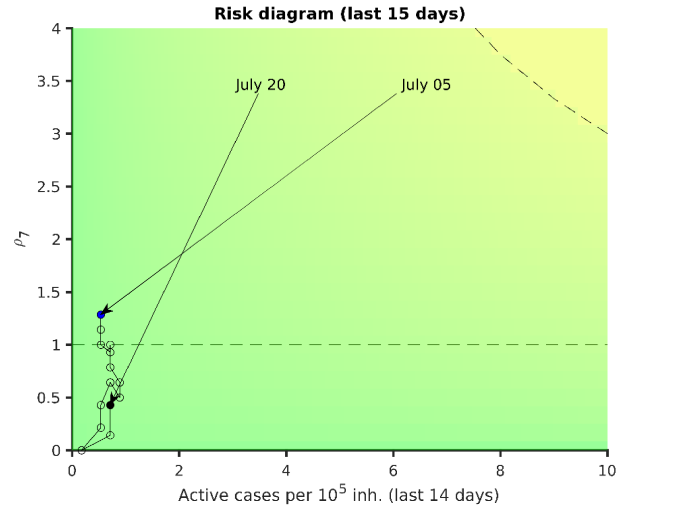












Methods

Methods

(1) Data source

Data are daily obtained from World Health Organization (WHO) surveillance reports[3], from European Centre for Disease Prevention and Control (ECDC)[4] and from Ministerio de Sanidad[5]. These reports are converted into text files that can be processed for subsequent analysis. Daily data comprise, among others: total confirmed cases, total confirmed new cases, total deaths, total new deaths. It must be considered that the report is always providing data from previous day. In the document we use the date at which the datapoint is assumed to belong, i.e., report from 15/03/2020 is giving data from 14/03/2020, the latter being used in the subsequent analysis.

(2) Data processing and plotting

Data are initially processed with Matlab in order to update timeseries, i.e., last datapoints are added to historical sequences. These timeseries are plotted for EU individual countries and for the UE as a whole:

- ✓ Number of cumulated confirmed cases, in blue dots
- ✓ Number of reported new cases
- ✓ Number of cumulated deaths

Then, two indicators are calculated and plotted, too:

- ✓ Number of cumulated deaths divided by the number of cumulated confirmed cases, and reported as a percentage; it is an indirect indicator of the diagnostic level.
- ✓ ρ: this variable is related with the reproduction number, i.e., with the number of new infections caused by a single case. It is evaluated as follows for the day before last report (*t-1*):

$$\rho(t-1) = \frac{N_{new}(t) + N_{new}(t-1) + N_{new}(t-2)}{N_{new}(t-5) + N_{new}(t-6) + N_{new}(t-7)}$$

where $N_{new}(t)$ is the number of new confirmed cases at day *t*.

(3) Classification of countries according to their status in the epidemic cycle

The evolution of confirmed cases shows a biphasic behaviour:

(I) an initial period where most of the cases are imported;
(II) a subsequent period where most of new cases occur because of local transmission.

Once in the stage II, mathematical models can be used to track evolutions and predict tendencies. Focusing on countries that are on stage II, we classify them in three groups:

- Group A: countries that have reported more than 100 cumulated cases for 10 consecutive days or more;
- Group B: countries that have reported more than 100 cumulated cases for 7 to 9 consecutive days;
- Group C: countries that have reported more than 100 cumulated cases for 4 to 6 days.

[3] https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports
[4] https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases
[5] https://www.mscbs.gob.es/profesionales/saludPublica/ccayes/alertasActual/nCov-China/situacionActual.htm https://github.com/datadista/datasets/tree/master/COVID%2019 , https://covid19.isciii.es/

(4) Fitting a mathematical model to data

Previous studies have shown that Gompertz model[6] correctly describes the Covid-19 epidemic in all analysed countries. It is an empirical model that starts with an exponential growth but that gradually decreases its specific growth rate. Therefore, it is adequate for describing an epidemic that is characterized by an initial exponential growth but a progressive decrease in spreading velocity provided that appropriate control measures are applied.

Gompertz model is described by the equation:

$$N(t) = K\, e^{-ln\left(\frac{K}{N_0}\right)\cdot e^{-a\cdot(t-t_0)}}$$

where *N(t)* is the cumulated number of confirmed cases at *t* (in days), and N_0 is the number of cumulated cases the day at day t_0. The model has two parameters:

- ✓ *a* is the velocity at which specific spreading rate is slowing down;
- ✓ *K* is the expected final number of cumulated cases at the end of the epidemic.

This model is fitted to reported cumulated cases of the UE and of countries in stage II that accomplish two criteria: 4 or more consecutive days with more than 100 cumulated cases, and at least one datapoint over 200 cases. Day t_0 is chosen as that one at which *N(t)* overpasses 100 cases. If more than 15 datapoints that accomplish the stated criteria are available, only the last 15 points are used. The fitting is done using Matlab's Curve Fitting package with Nonlinear Least Squares method, which also provides confidence intervals of fitted parameters (*a* and *K*) and the R^2 of the fitting. At the initial stages the dynamics is exponential and *K* cannot be correctly evaluated. In fact, at this stage the most relevant parameter is *a*. Fitted curves are incorporated to plots of cumulative reported cases with a dashed line. Once a new fitting is done, two plots are added to the country report:

- ✓ Evolution of fitted *a* with its error bars, i.e., values obtained on the fitting each day that the analysis has been carried out;
- ✓ Evolution of fitted *K* with its error bars, i.e., values obtained on the fitting each day that the analysis has been carried out; if lower error bar indicates a value that is lower than current number of cases, the error bar is truncated.

These plots illustrate the increase in fittings' confidence, as fitted values progressively stabilize around a certain value and error bars get smaller when the number of datapoints increases. In fact, in the case of countries, they are discarded and set as "Not enough data" if $a>0.2\ day^{-1}$, if $K>10^6$ or if the error in K overpasses 10^6.

It is worth to mention that the simplicity of this model and the lack of previous assumptions about the Covid-19 behaviour make it appropriate for universal use, i.e., it can be fitted to any country independently of its socioeconomic context and control strategy. Then, the model is capable of quantifying the observed dynamics in an objective and standard manner and predicting short-term tendencies.

(5) Using the model for predicting short-term tendencies

The model is finally used for a short-term prediction of the evolution of the cumulated number of cases. The predictions increase their reliability with the number of datapoints used in the fitting. Therefore, we consider three levels of prediction, depending on the country:

[6] Madden LV. Quantification of disease progression. Protection Ecology 1980; **2**: 159-176.

- Group A: prediction of expected cumulated cases for the following 3-5 days[7];
- Group B: prediction of expected cumulated cases for the following 2 days;
- Group C: prediction of expected cumulated cases for the following day.

The confidence interval of predictions is assessed with the Matlab function `predint`, with a 99% confidence level. These predictions are shown in the plots as red dots with corresponding error bars, and also gathered in the attached table. For series longer than 9 timepoints, last 3 points are weighted in the fitting so that changes in tendencies are well captured by the model.

(6) Estimating non-diagnosed cases

Lethality of Covid-19 has been estimated at around 1 % for Republic of Korea and the Diamond Princess cruise. Besides, median duration of viral shedding after Covid-19 onset has been estimated at 18.5 days for non-survivors[8] in a retrospective study in Wuhan. These data allow for an estimation of total number of cases, considering that the number of deaths at certain moment should be about 1 % of total cases 18.5 days before. This is valid for estimating cases of countries at stage II, since in stage I the deaths would be mostly due to the incidence at the country from which they were imported. We establish a threshold of 50 reported cases before starting this estimation.

Reported deaths are passed through a moving average filter of 5 points in order to smooth tendencies. Then, the corresponding number of cases is found assuming the 1 % lethality. Finally, these cases are distributed between 18 and 19 days before each one.

[7] At this moment we are testing predictions at 4 days for countries with more than 100 cumulated cases for 13-15 consecutive days, and 5 days for 16 or more days.

[8] Zhou et al., 2020. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. The Lancet; March 9, doi: 10.1016/S0140-6736(20)30566-3